December 1988/January 1989

AIR & SPACE

Smithsonian

Masters of Soaring:
an aerial contest on
silent wings

WILLIAM THE CONQUEROR AND AIR SUPERIORITY

In 1066 one of the most decisive battles in the history of the world was fought. William, Duke of Normandy, ventured an invasion of England in the face of a formidable opponent. But one of the reasons that gave him the confidence to try such a risky undertaking was that he had a recently invented technological edge that the English did not.

That edge was the stirrup.

While the English rode to the battlefield, they fought on foot; conventional wisdom being that the horse was too unstable a platform from which to fight. But the Norman cavalry, standing secure in their stirrups, were

Bayeux Tapestry, Anon. C. 1077, Bayeux, France

able to ride down the English, letting the weight of their charging horses punch their lances home.

This technological edge led to the conquest of Britain. Without it, William might never have attempted such a perilous war. And this very ad might have been written in Anglo-Saxon.

There are two lessons here, lessons that have been repeated endlessly throughout history. The first is that technological differences can lead to the rise or downfall of great civilizations. The second is that, emboldened by such advantages, a potential adversary may risk war.

The laws of history have not changed. In our own time we find ourselves jockeying for the technological edge. The Warsaw Pact is expected to produce an air superiority fighter in the mid-1990s. This is where America's Advanced Tactical Fighter comes in. A culmination of the most far reaching technology in history, the ATF will effectively check a potential imbalance in air defense, and so preserve stability.

If, almost a millennium ago, the English had had some effective counter to the Norman cavalry, William might have had second thoughts about crossing the Channel. Applying that timeless lesson today, we know that defenses such as the Advanced Tactical Fighter will give second thoughts to anyone thinking that now is his chance.

Lockheed
Giving shape to imagination.

December 1988/January 1989
Volume 3, Number 5

AIR&SPACE
Smithsonian

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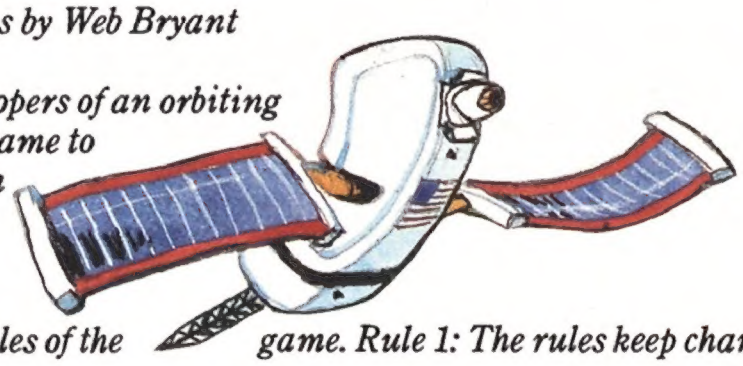

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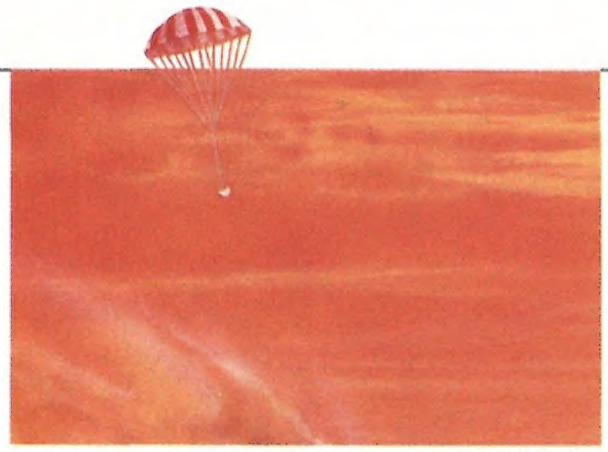

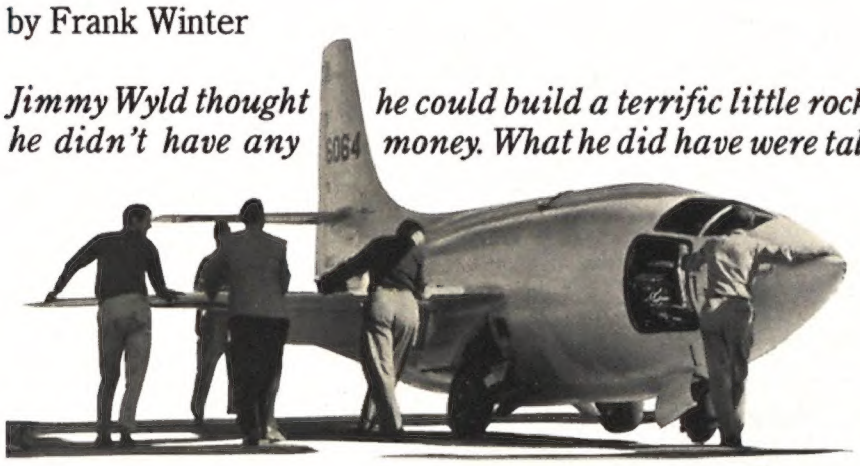

Cover: *Christopher Woods' remote camera recorded two Masters competitors in close formation.*

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Room to Grow

What does an air and space museum do when airplanes and spacecraft continue to grow, both in size and in weight? Traditionally, museums have been built in city centers. But such a location is virtually inaccessible to large airplanes and spacecraft.

At the National Air and Space Museum, most of our aviation exhibits begin with the restoration of aircraft at our Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland. Once the restoration is completed, the wings are detached from the fuselage, the individual parts are trucked to the Museum, and the components are then reassembled in the gallery where the exhibit is to be mounted. But only small airplanes can be managed in this fashion. Beyond a certain size, even individual components become too bulky for such handling. Furthermore, the flying machines of today are much too heavy even for the six-inch-thick concrete floors at the Museum. Large aircraft must have far thicker runways, taxiways, and ramps, all of which comprise 12-inch-deep expanses of concrete supported by solid ground.

The Museum is particularly pleased that the first of the space shuttles, the *Enterprise,* is now in our care. This spacecraft was never taken into Earth orbit; it was flown mainly to test glide landings. It is currently in storage at the Washington Dulles International Airport because it cannot be displayed in the Museum. Even if we were able to transport the shuttle downtown, it could not fit into the building. And if it could, its enormous weight would still be a problem.

If the shuttle and large aircraft cannot be brought to the Museum, then a part of the Museum must move to where the aircraft are. During the past few years, we have become convinced that a Museum extension with ready access to long airport runways is essential if we are to carry our Congressional mandate to memorialize aviation and spaceflight forward into the 21st century. We cannot continue to portray the progress of the United States and other nations if we have to limit ourselves merely to the exhibition of models and photographs. If we do not display real artifacts we will cease to be a museum that is able to meet our visitors' expectations.

During the past year, the Museum has conducted a study to determine our requirements for an extension of the Museum. We concluded that we should build a facility where we could display airplanes and spacecraft in a setting that would drive home the full impact of manned and unmanned flight on the way we live and on the ways in which we view Earth, its resources, and the environmental impact of spreading industrialization. We also want to be able to show the influence of mass air travel, which has enabled millions of us to witness the global problems of mankind and confront vital questions involving international relations. We would like to be able to portray not only the benefits of flight but also some of its more threatening aspects: bombers that can penetrate deep into a nation's heartland and rockets that can strike anywhere on Earth with less than half an hour's warning.

Our study also dealt with structural and organizational questions. We asked how the extension should complement the current museum, what its dimensions should be, what fraction of the buildings would consist of large hangars for displaying massive airplanes and spacecraft, and what portion would be needed for galleries designed around a central theme.

We decided that the extension would have to be built within an hour's drive from the Mall, so that both facilities could be serviced by one well-integrated staff. That limits the choice to two locations: Dulles Airport and the Baltimore-Washington International Airport. The Regents of the Smithsonian Institution accordingly have directed the Museum to investigate those two sites and report back with a decision, preferably within a year. We are about to embark on that study, and I will keep our Associate members informed of our progress.

—Martin Harwit, Director, National Air and Space Museum

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Letters

Second Chance

As a survivor of two aircraft crashes, I understand Bill Moore's Groundling's Notebook (August/September 1988) from the other side.

In March 1966, I missed a flight to New Orleans because of a traffic jam. I caught a later flight, and it never occurred to me that something had happened even when the flight was re-routed for a long stopover in Atlanta due to "bad weather." When I landed in New Orleans and saw a bright fire smoldering alongside the airport, it still did not occur to me that there had been a crash. It was only after checking into my room and turning on the radio that I learned what had happened to the flight I missed.

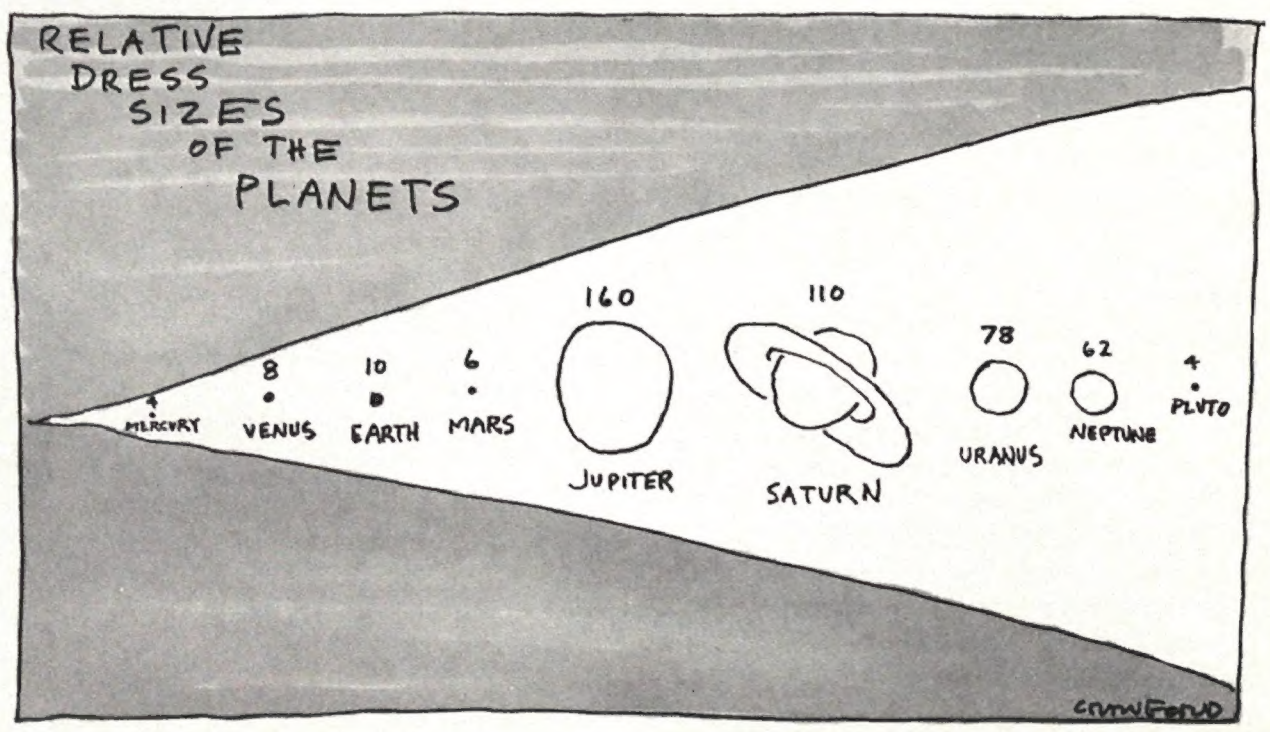
My second miss occurred in 1967, when a jet crashed in Burlington, Vermont. Again I had a reservation, but because of missed connections I didn't make the flight. After making other flight arrangements I called my office and didn't quite understand the response I received. My office had already heard about the crash and my secretary was distraught. When the receptionist told her that I was on the phone she became angry, thinking the girl was playing a cruel joke. In the meantime I had to hang up to catch my flight and the dead line at the office added further to the confusion. When I later reached my secretary, her response was "It really *is* you!"

It took me quite some time to get over the initial shock of this second miss. As Bill Moore said, "We will never be our old selves again." Personally, I am thankful to God that I'm not my old self. A stone heart was changed to a heart with compassion and caring. I have become a new creature.

Raymond W. Doreian
King of Prussia, Pennsylvania

Exchanging Words

In his letter on the subject of *venusian/venerian* in the August/September 1988 issue, Victor Koman is, to be blunt, wrong. While *venusian* may indeed be poorly formed from the standpoint of Latin practice, there is absolutely nothing wrong with its formation in English. As part of our ongoing concern at Merriam-Webster with the ways in which words are used, we have collected more than 13.5 million examples of the uses of words in context, and *venusian* is by far the most popular choice for the adjective meaning "of or relating to the planet Venus." For Mr. Koman's



You should see what happened to the train.

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alternative of *venerian,* we have not a single instance (though we have three examples of the spelling *venerean*). We have citations for *venusian* from at least 17 different sources, both general and technical.
Paul F. Cappellano
Physical Sciences Editor
Merriam-Webster Inc.
Springfield, Massachusetts

On the Wing

In Calendar for the October/November 1988 issue, the entry for October 21, 1947, implies that Northrop's YB-49 flying wing bomber crashed because of structural failure. This is an oversimplification.

The crash of the No. 2 Northrop YB-49 in 1948 occurred following acceptance of the aircraft by the Air Force. Refusing a check-out by Northrop civilian test pilots, the military crew took off on what was only their fourth flight in the YB-49, and after only 11 hours' total flight time in the flying wing. Considering the crew's lack of experience in the airplane, one might ask who ordered them to perform sophisticated flight test procedures involving engine-out performance and stalls, rather than getting a check-out by the more experienced pilots.

It is obvious from all evidence that the inexperienced pilot at the controls exceeded the redline speed of the YB-49 (650 mph) in the process of pulling out from a power-on stall. The jet-powered YB-49 aircraft, with an XB-35 airframe engineered and stressed for installation of lower-powered piston engines, broke apart and disintegrated in flight. No static stress test had been conducted on the YB-49 airframe.
Robert Wenkam
Irvine, California

Editor's note: Robert Wenkam is the co-author, with Ted Coleman, of Jack Northrop and the Flying Wing *(see Reviews and Previews, p. 100).*

Tie Breaker

I thoroughly enjoyed your refreshingly honest portrait of Soviet scientist Roald Sagdeev ("The Space Statesman," October/November 1988). But while author Nicholas Daniloff appears to be a good judge of character, he's a lousy judge of fashion. The tie Sagdeev is wearing in one of the article's photographs is not embroidered with "2001," as Daniloff asserts, but with "2061." The "6" is a stylized representation of the head and tail of Halley's Comet, which will next return in that year. Also, twice the article mentions a laboratory at "Akademgorok." The correct transliteration is "Akademgorodok," which means "academic town." The best translation I can come up with for "Akademgorok" is "academic peas."
Richard Tresch Fienberg
Associate Editor
Sky & Telescope
Cambridge, Massachusetts

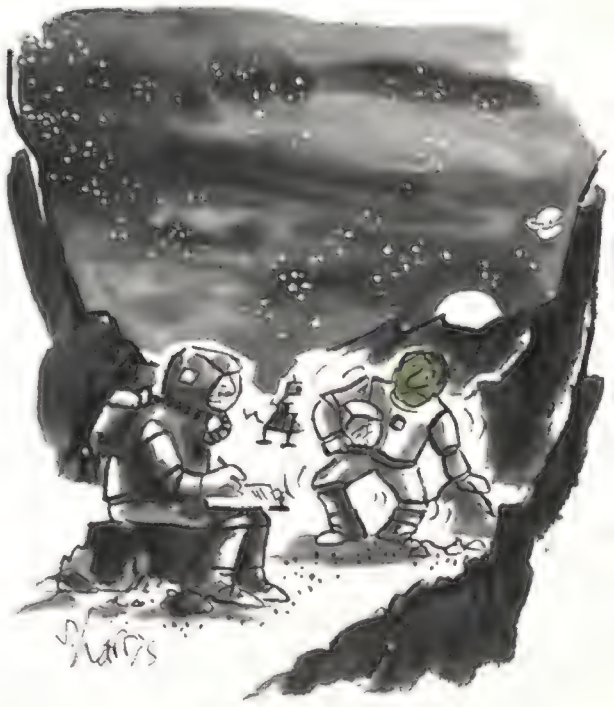
To Me or Not to Me

I hope that Donald G. Kloenne's letter in the October/November 1988 issue on the "Me-109 or Bf-109" question sparks more response. His information was correct, but only technically so. The Luftwaffe did indeed retain the earlier designation, Bf-109, despite the fact that in 1938, following reorganization, the Bayerische Flugzeugwerke became Messerschmitt AG. With the E series the factory re-designated the fighter the Me-109.

Airmen on both sides of the conflict, including Douglas Bader and Adolf Galland, referred to this aircraft as the Me-109, so painter Robert Taylor's term is consistent with the flavor of the period. That the Luftwaffe had never officially changed its designation of the 109 was a somewhat obscure fact noted by only a relatively few historians until long after World War II.
S. James Dankert
Bourbon, Indiana

Fan Mail

I must thank you folks for the excellent article "The Lear Fan Saga" (October/November 1988), but a more complete



Atmosphere: hostile.

explanation should be made of the component failures that occurred during certification testing. This type of durability testing places the airframe under greater stresses than the aircraft would encounter in normal flight.

During the Reno Air Races, I saw the Lear Fan in flight several times and it was hard to believe that it was propeller-driven; the aircraft was incredibly quiet and smooth and consumed about one-third the fuel the typical Learjet uses.
Andrew M. Kubiak
Gary, Indiana

T.A. Heppenheimer's article begins and concludes with Lear's 70-year-old widow tending "the dying embers of this, his last vision" by waiting for the phone to ring. That is both ignorant and uncaring. Moya Lear is certainly "keeping the faith," but not by a quiet telephone. She is asked to speak nationwide on behalf of cultural and political interests, to aviation groups, and at commencements. She holds honorary doctorates, stays active in her community, and is contemplating writing a book.
Chris Crockett
Reno, Nevada

Department of Corrections Department

The typographical error on page 32 of the October/November 1988 *Air & Space/Smithsonian* is both dramatic and surprising. The typographical error on page 32 of the October/November 1988 *Air & Space/Smithsonian* is both dramatic and surprising.
Lin Chapman
Wallingford, Connecticut

In "The International Airplane" (October/November 1988) Yugoslavia is referred to as a Baltic nation. I'm sure the residents of this Adriatic country will be pleased with the more bracing climate they'll find after moving 1,500 miles north!
Tom Shatten
Pittsburgh, Pennsylvania

Editor's note: Yugoslavia is, in fact, a Balkan *nation.*

Air & Space/Smithsonian *welcomes comments from readers. Letters must be signed and may be edited for publication. Address letters to* Air & Space/Smithsonian, *National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.*

Taking Liberty

On the floor of the Atlantic Ocean near the Bahamas lies the *Liberty Bell 7,* the only NASA spacecraft lost after a manned mission. The capsule sank after astronaut Virgil Grissom made a 15-minute ballistic flight 118 miles into space on July 21, 1961. It was the second flight of the Mercury program, made two months after Alan Shepard's similar launch and seven months before John Glenn's Earth orbits.

Twenty-seven years after Grissom's flight, Curt Newport of Annapolis, Maryland, is leading an effort to recover the sunken capsule. "There's a piece of American space history out there," says Newport, a Mercury program enthusiast, "and we believe we can locate it. And if it can be located, then it can be recovered."

Grissom splashed down 300 miles southeast of Cape Canaveral and about 150 miles east-northeast of Grand Bahama Island. While he waited for the recovery helicopters, the escape hatch suddenly blew off. Ordinarily an astronaut must prime and fire explosive bolts to open the hatch, but Grissom said he "was just lying there and it blew." As seawater poured into the hatch, Grissom bailed out. One helicopter retrieved the foundering astronaut, whose suit was also filling with water, while the other fought a losing battle with the waterlogged *Liberty Bell 7,* now nearly double its normal weight. When a warning light indicated that the helicopter could no longer support it—later found to be a false alarm—the pilot released the line and the capsule sank to the ocean floor. To this day no one knows precisely what caused the hatch to blow. (Grissom died in 1967 in an Apollo training capsule fire.)

Newport, who has spent 11 years as an underwater salvage expert, helped recover pieces of the *Challenger*'s rocket boosters and has also helped find airline wrecks submerged in 14,000 feet of water. Assisting him in the *Liberty Bell* effort is Gregg Linebaugh, a remote sensing specialist at NASA's Goddard Space Flight Center and an amateur NASA historian, as well as former Gemini and Apollo astronaut Thomas Stafford, who managed to wangle a blueprint of the Mercury capsule from its

NASA

builder, McDonnell Douglas.

But before Newport raises the *Liberty Bell* he must first raise $430,000 to get the search under way—as early as next June, should funding come through. He plans to explore the area's ocean floor, which is 16,000 feet below the surface, with a towable underwater platform equipped with lights and cameras, similar to ANGUS (acoustically navigated geological underwater surveyor), the submersible used to find the *Titanic* at 13,000 feet. If Newport finds the tiny 2,800-pound capsule, he figures he will need another $97,000 to recover it with a winch and a high-strength line.

NASA has issued no statement on the project but maintains that any space program artifact remains agency property until it is released to the National Air and Space Museum, which has dibs on any NASA craft. Newport's attorney disagrees—he argues that anything recovered in international waters, which begin 200 miles offshore, belongs to the finder. "But we don't want to get in a fight over who owns it," says Newport. "All we want to do is find a museum to give it to."

—Matt Schudel

Bright Lights, Big Problem

The slide projected on the wall of the darkened conference room looked like a star field, but the 120 astronomers studying it weren't fooled. They nodded grimly as their colleague David Crawford explained that it was a satellite night view of the southwestern United States, only one of many urban sprawls where "sky glow" is hiding the stars. Sky glow, the excess light that shines upward instead of down on the streets, signs, buildings, and sports fields it is intended to illuminate, is known to astronomers by a more down-and-dirty name: light pollution. The International Astronomical Union convened in Washington last August to discuss what astronomers could do about it, as well as the radio interference and space debris that threaten their profession.

Bad lighting "is removing parts of our universe from view faster than a redshift," said Crawford, who was demonstrating the kind of slide show that could be presented to local governments, lighting engineers and designers, architects, and real estate developers under the banner "Save the Stars." His presentation emphasizes the lower cost of "the right amount of light" and estimates that the United States wastes $1.3 billion a year on electricity that "only lights the bottoms of airplanes."

Crawford has had a lot of experience in this line of evangelism. During his 10 years at Arizona's Kitt Peak National Observatory, the home of the third largest optical telescope in the United States, he has been "marketing quality lighting almost full time" to protect the sky from the intrusive lights of Tucson and Phoenix.

Tucson adopted a lighting ordinance to control sky glow in 1972, after Crawford's predecessor, Arthur Hoag, explained the hazard and proposed a cost-saving plan to city officials. The ordinance prohibits the non-emergency use of searchlights and certain other kinds of outside lighting between midnight and sunrise; it also requires ultraviolet filters on mercury vapor and high-pressure sodium lamps, as well as shields on fixtures to direct the light away from the sky and toward its target.

There are now more than 40 lighting control ordinances in Arizona. Communities in Southern California have followed suit, but not soon enough to save the 100-inch telescope at Mt. Wilson Observatory in Los Angeles from retirement. "Sky brightness in Los Angeles was a heavy influence in the decision by the Carnegie Institution that their resources were better channeled to Chile," says Crawford. Today, even with

NOAO

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As with any insurance policy, there is the fine print to consider. The Frequent Flyer Exclusion limits benefits to one occurrence per policyholder, and you will have to provide proof of abduction. On the other hand, you receive a policy suitable for framing or gift-giving.

St. Lawrence says he has to disqualify some applicants: "Anyone who takes it seriously—we'll cover everyone else." But he says abductees can count on him, provided they're patient. "If we have to pay off on a claim we'll spread it out. Say, one dollar a year for 10 million years."

St. Lawrence is an accountant when not pushing indemnification, a field he's dabbled in before. His Future Life Insurance Company offered $10 million reincarnation compensation—$20 million if you returned as a lower life form. The first policy was sent gratis to Shirley MacLaine.

The UFO policy took shape about the time Whitley Strieber's book *Communion* hit the charts and St. Lawrence discovered that his own policies didn't cover interplanetary kidnapping. Nine months after he began chatting up his plan on radio talk shows, over 2,000 clients had signed on, "mostly from California, as you might expect," says St. Lawrence, "but there's a monastery in Greece with full coverage."

St. Lawrence has also had his share of irate responses, claiming he is belittling serious UFO research. He disagrees. "We need to laugh about UFOs, not to mention insurance. Especially if any of these UFO stories are true. Then we'll *really* need a sense of humor."

—Thomas Bedell

lighting restrictions, and even though San Jose, Long Beach, and San Diego have retrofitted their street lighting systems with low-pressure sodium lamps, the area's population explosion has doubled the background brightness of the night sky.

Astronomers are banding together in a new consciousness-raising group, the International Dark-Sky Association, to fight light pollution. IDA members are concerned not only about the hazards to science but about the fact that sloppy lighting is stealing something precious from the people who live in cities. To astronomers, the night sky is a birthright, like pure oceans or clean air. Billboards, parking lots, sports arenas, and some street lighting systems are the largest offenders, but IDA members will also tell you, gently but firmly, that you could be littering every time you flick a switch on your back porch.

Astronomers at the IAU colloquium responded gravely to questions from the press about the dangers of light pollution, radio interference, and space debris. One reporter suggested that the far side of the moon was the best hope for a scientific preserve, but the astronomers were unwilling to give up on Earth-based observing. Besides, they added, the polluters may get there first.

—Linda Shiner

Ah, To Be in England Now That MiGs Are Here

News that the Soviets were bringing a pair of their seldom-seen MiG-29 fighters to the Farnborough aerospace exhibition in England last September raised the event's standing to new and glorious heights. In the years following its first sighting in 1981,

GEORGE HALL

the top-secret product of the A.I. Mikoyan Design Bureau only grudgingly gave up its secrets to piecemeal deductions, insights, and one notable public appearance in Finland in July 1986. To have it flying daily routines for two weeks at Farnborough with the rest of the world's top fighters was a coup that loosed a volley of press releases from the normally unflappable Society of British Aerospace Companies, the exhibition's host organization.

Two days before the show's official opening, we got word that the MiGs would arrive late that afternoon. Under the tents, acres of products and partitions were being whipped into shape by an army of workers and exhibitors sweating side by side. As the warm afternoon wore on they drifted outside to grab a beer and a smoke and scan the eastern sky. Would the MiGs really show? Was it a trick?

Suddenly two green- and gray-mottled fighters with red stars on the wingtips and vertical tails streaked in low, wings nearly overlapping, escorted by a pair of Royal Air Force Tornados. At midfield the Tornados peeled off and the MiGs tore into an impromptu aerobatic exhibition. They arced into a perfect loop, swept down to race across the field, banked sharply around the airport perimeter, then crossed the field again and climbed steeply. Dressed for landing with gear down and lights blazing, they approached in trail formation and touched down gently. Drag parachutes blossomed from their tails to shorten the landing roll. The crowd erupted in cheers and applause.

The next day a lone MiG flew its airshow routine for the conservative Farnborough Safety Committee. There was a breathtaking knife-edge flyby the length of the runway, then a dramatic tailslide at 3,000 feet. The committee asked to see it again—would the judges perhaps hold up scorecards with 8s and 10s scribbled on them?—and the pilot obliged. The tailslide was approved for the daily flight, though at a higher altitude than that at which it had been practiced.

On the final day of the show the Soviets did a little grandstanding by flying their bad-weather routine, a series of tight turns, knife-edge passes, and high-angle-of-attack maneuvers used when a low ceiling prevents climbs and loops. The Mikoyan team's chief pilot, Anatoli Kvotchur, said he merely wanted to show off the airplane's turn capability, and so he did, with bravura flying that drew rave reviews even from the safety committee.

The Soviets had arranged for a press conference at show's end, and security was tight as the media descended on the Soviet Embassy, an old mansion on a secluded street in London's Kensington Park district. After we were shepherded into a cavernous room already stuffed with reporters and cameramen jockeying for position, a dozen Soviet government and industry representatives and a translator filed in solemnly and sat at a long table. Most questions were related to design details, production, and quality control and were answered forthrightly. Others, such as "How many MiG-29 squadrons are there and where are they based?" were politely refused. The answer to "When do you expect to discontinue production?" was a simple "When they are no longer necessary." One question, something about sending Raisa Gorbachev into space, left audience and panel in stunned silence.

When the conference ended I caught up with Mikoyan's chief design engineer, Rostislav Belyakov, and asked for a business card. As we shook hands Belyakov reached into his pocket, then pressed a small lapel pin in my hand. I had forgotten the proclivity of the Soviets for exchanging trinkets with foreigners in the hope of receiving a memento to add to their collections. I frantically searched my pockets for something distinctively American and found a coin. Belyakov was pleased but somewhat puzzled—like many Americans, he had probably never seen it before. We parted with pleasantries, I with my tiny MiG-29 pin, he with his Susan B. Anthony dollar.

—Robert B. Parke

But Were the Drinks Free?

Vacationers flying home to London from Portugal's Madeira Islands off Morocco last August paid a considerable fuel surcharge—up to $1,000 per passenger—on top of their ticket fees.

The temporary rate increase occurred on a Caledonian Airways flight from Funchal to Gatwick. The Boeing 737 made a routine stop at Madeira's Porto Santo to refuel for the overwater haul to London. When the captain pulled out his Shell credit card, the ground crew refused it. Likewise his American Express card. They were expecting a Gibraltar Airways 737, they said, not a Caledonian aircraft.

Captain Smith explained that Gibraltar, which usually flies the route, had equipment trouble and had rented the Caledonian 737 to fill in. The Porto Santo people were dubious. Smith called British Airways (parent company for Caledonian), the Funchal airport, another fuel company on Porto Santo—all to no avail. He could pay cash, the ground crew said, or he could sit there until hell froze over or someone cleared up the problem, whichever came first.

Smith went back to the airplane and related all this to his 100 passengers, who chose not to wait for assistance. They pulled out their wallets and came up with $2,000, with one man contributing half. Smith flew on to Gatwick, where British Airways reimbursed everyone. And followed up later with a nice thank-you note.

—Patricia Trenner

Frozen Assets

For nearly 50 years Norman Vaughn has dreamed about the bleak, windswept ice cap of east-central Greenland—or more precisely, about a flight of World War II airplanes buried beneath it. Since 1981 Vaughn has been searching for six P-38 Lightnings and a pair of B-17s forced down on July 15, 1942. But more than four decades of Arctic winters have sufficiently engulfed the aircraft to thwart all attempts to find them.

This year Vaughn got lucky. Using low-frequency radar and a steam-powered drilling probe, he and members of the Atlanta-based Greenland Expedition Society located all eight airplanes during a six-week search last summer. However, the hulks are 260 feet down, not 60 to 80 feet, as some reports had speculated. "There had been a lot of confusion over the years as to their depth," says Austin Kovacs, the team's geophysics and drilling specialist. "In fact, some had even claimed to see them sitting on top of the ice as late as the 1960s."

Flying under the code name "Bolero," the fighters and bombers were being ferried by the U.S. Army Air Forces to the Eighth Air Force in England when they encountered bad weather between Greenland and Iceland. With fuel running low, the pilots turned back to Greenland, where they were forced to land about 18 miles inland. One of the P-38s lowered its landing gear, touched down, then flipped over; the rest of the pilots opted to belly onto the slick ice.

None of the 25 crewmen was injured, and rescuers reached them via dogsled nine days later. Vaughn, an air force major and expert musher flown in from Maine to aid in the salvage effort, returned a few weeks later to recover a top-secret Norden bombsight accidentally left in one of the B-17s. The military made no further attempt to salvage the airplanes.

Today only a handful of P-38s and B-17s are flying. Vaughn, 82, says he is in it for the adventure, but to expedition leaders Pat Epps and Richard Taylor the squadron represents millions in salvage value. In fact, two of the P-38s sustained so little damage that Epps and Taylor think they may be able to repair them on site and fly them to an airport for a thorough inspection.

But finding the aircraft was only half the battle. Tunneling with a one-inch probe is one thing, but making 260-foot-deep holes the size of a B-17 is another. "We'll use jackhammers," Vaughn says, "under the supervision of engineers." That monumental task will get under way next summer—if Epps, Taylor, and Vaughn can

find investors to bankroll the $2 million operation.

Should the recovery attempt succeed, one P-38 will go to the Danish government, which permitted the search on its island. Then Vaughn will return home to Trapper Creek, Alaska, and the last of the Bolero squadron will be sold to wealthy aficionados of aviation history.

—J. Kelly Beatty

Elegy in an Airport Bar

Muse Air was always a little different. Its founder, Lamar Muse, named the airline after himself. Its female flight attendants wore skirts slit to mid-thigh. Its aircraft seats were leather. And long before the Federal Aviation Administration mandated it, Muse Air banned smoking.

For four years Muse's white MD-80s and DC-9s flew the southwest skies. But despite its sophisticated image Muse Air suffered mounting losses, and in June 1985 it was purchased by Southwest Airlines and renamed Transtar.

Muse's fiscal misfortunes plagued its successor; Transtar lasted only two years. But for the 1,300 employees who kept the two fledgling airlines flying, the Muse/Transtar experience so transcended the typical job that they held a funeral for their airline when it shut down. And one year after the last flight, 800 alumni turned out for the airline's first reunion, held in Houston last August.

The Cockpit Bar, across the street from Hobby Airport, is owned by five former Muse pilots; it was the ideal site for the event. With DC-10 schematics, MD-80 cockpit diagrams, and photos of jet fighters on the walls, the Cockpit is accustomed to catering to an aeronautical crowd. This crowd, however, partied for five days.

Although rock bands in the bar's parking lot provided a steady beat and the beer flowed freely, an air of nostalgia permeated the gathering. Most were there to reminisce about a business dramatically altered by deregulation.

The days when pilots spent their entire flying careers with one airline are rapidly disappearing. Rik Crews, who flew for both Muse and Transtar, is not yet 30 and has already flown for five airlines. He likened flying for Muse to being a member of an extended family. "I actually knew the scheduler who assigned our flights," Crews said. "Where I'm working now, I check in by computer, receive my flight assignment, and go to work without ever really talking to anybody."

In the lounges the common topics were seniority and who was hiring. "Mergers are changing everything," said Alan Reeve. "In any merger some pilots are going to take it in the shorts." Pilots from different carriers used to talk to one another, he says, but now, with everyone in the cockpit posing a potential threat to another's job, crews keep to themselves.

Mergers can drastically alter a pilot's seniority, and seniority controls assignments, vacations, days off, advancement possibilities, and even where a crew member lives. "They say move to Newark, you move to Newark," said one pilot. "I lived in Newark for five months. You ever lived in Newark?"

Most of the pilots and flight attendants who worked for Muse/Transtar lived in Dallas and Houston. There were company picnics and chili cook-offs. Flight attendant Holly Martin recalls them fondly—her son was born the day of a company picnic in 1984. During her pregnancy, when her flying was limited, supervisors shifted her from department to department to ward off boredom. "There was a closeness, a camaraderie," said flight attendant Corky Thomason. "Today's airlines are just too big for that kind of feeling."

Many of Muse/Transtar's former employees now work for large carriers and make more money. With giants to slay, the two startup airlines kept wages low. Still, family ties are strong, and the organizers say they'll hold reunions as long as someone's willing to come.

—Byron Harris

KYLE MILLER

License, Registration, and Antlers, Please

The Lone Ranger had Silver. Batman had his Batmobile. And Sergeant Dave Lorring, an Alaska State Trooper, has a Super Cub on floats. When the bad guys fly airplanes, the forces of law and order must follow. In a state with about 500,000 residents scattered across 591,000 square miles and few roads between distant towns, the logical way to patrol is from the air.

Lorring works for the Division of Fish and Wildlife Protection, which is responsible for enforcing Alaska's hunting and fishing regulations. The division maintains a small air force of 32 craft, and nearly a third of the 84 troopers assigned to Fish and Wildlife are pilots.

Lorring covers some 17,000 square miles that surround Anchorage. His Super Cub is stationed at Lake Hood, a seaplane base next to Anchorage International Airport. During September, which is moose hunting season, it's not uncommon to see floatplanes landing with a set of antlers tied to the struts to prove that the bagged moose was a male of legal size.

"We had a report from a pilot who saw two dead moose in a clearing over by Figure Eight Lake," Lorring says, pulling on his waders, "so we're flying over there to investigate."

The troopers often rely on anonymous tips to chase down violators. Alaska Fish and Wildlife Safeguard, a citizen's group, has established a fund to reward callers if their reports lead to citations or arrests. Most callers, however, offer the information without seeking the reward.

A spacecraft that was sent to explore the planet Venus for eight months completed its first decade of space service. The Hughes Aircraft Company-built Pioneer Venus Orbiter was originally slated to circle the planet for one complete Venus rotation, approximately 243 Earth days, and provide the first topographic maps of the planet. However, its unexpected longevity has given scientists detailed information not only about Venus but also about comets that have streaked within sight of the probe. Despite its 10 years, the orbiter shows little sign of wear and is expected to operate for another four years until its fuel runs out.

A new radar system is used to measure the radar reflectivity of an object. The radar cross section (RCS) measurement system can reproduce a two-dimensional image of a target, such as an aircraft, and the information can be used to help redesign the aircraft to reduce its visibility to enemy radar, resulting in "low observable," or stealth-type vehicles. The Hughes RCS system is universal and programmable, and is designed to take measurements over a broad band of microwave frequencies, from 0.1 to 100 gigahertz. The system can thus tell the user how visible a target would be to the "eyes" of any radar in the world.

An infrared sensor system for the joint services' V-22 Osprey aircraft will help crews navigate and land in darkness and during periods of poor visibility. The Infrared Detection Set (IDS), developed by Hughes, senses small differences in radiated heat and provides a TV-like image of the surrounding area. The V-22, the first of the new tilt-rotor aircraft for the U.S. Armed Forces, is able to take off and land like a helicopter, but fly like a plane. Hughes will start flight testing the IDS in early 1989, with flight test support continuing through 1991.

A new amplifying device can operate at much higher frequencies, and with lower noise, than traditional field-effect transistors. The High Electron Mobility Transistor (HEMT) device implemented in a new material system, pioneered and developed by Hughes, is fabricated by using indium phosphide as a substrate with gallium indium arsenide and aluminum indium arsenide grown onto it, one layer at a time, using a process known as molecular beam epitaxy. In a HEMT device, the semiconductor material containing the impurities is separated from the region of charge-carrying electrons, allowing the electrons to move much faster, so the device can operate at much higher frequencies, with lower noise, than an ordinary transistor. Potential uses include ultra-high frequency communication systems, high-speed radar signal processing equipment and high-power millimeter-wave circuits.

Hughes is seeking experienced engineers and scientists to design, develop, and produce Hughes' new line of body-stabilized HS 601 communications satellites. Openings are in the fields of: software, computers, and data processing systems; electrical components; microwave/RF communication systems development; on-board spacecraft electronics and control systems; satellite design, integration, propulsion, and electrical power system development; spacecraft manufacturing, systems test and evaluation; GaAs applications R&D. Send your resume to Michael Martinez, Hughes Space & Communications Group, Dept. S4, S4/A300, P.O. Box 92919, Los Angeles, CA 90009. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES

Subsidiary of GM Hughes Electronics

The two carcasses are about a mile from the lake where Lorring lands, requiring a half-hour wade through a bog. They had been shot and left, a misdemeanor punishable by at least a week in jail and a $2,500 fine for each animal. Why they were left is anyone's guess—most Alaskans prize moose meat, preferring it to beef. Lorring suspects that the hunter spotted the moose from his airplane, killed them the same day, then panicked, thinking he'd been reported.

"Same day airborne" is a common infraction, since most of Alaska's hunters travel by small aircraft. The Alaska Game Regulations state, "No person who has been airborne, except in regularly scheduled jet aircraft flights, may take or assist in taking a big game animal until after 3 a.m. following the day in which the flying occurred." This gives moose a fighting chance against hunters spotting them from the air, then landing nearby to pick them off. The penalties are severe:

JORDAN COONRAD

fines up to $5,000, a year in jail, and, for repeat offenders, seizure of the aircraft. A number of the division's aircraft have come from these seizures.

Lorring's investigation includes searching for clues near the kill site. He looks for spent shells and tries to determine the direction the shots came from. He calculates when the quarry was shot, then interviews anyone he finds in the area. Did they know about the dead moose? Where were they at the time of the crime? Did they see anybody suspicious? Hear anything? Was there an airplane nearby?

"If you can find where the animal was killed," says division director Jack Jordan, "there's usually a lot of evidence that will get you to the person you want. Then you look for enough probable cause to get a search warrant so you can search his airplane or house or car. If you kill a moose and put it in an airplane, it's almost impossible to get all the evidence out."

Lorring's work doesn't end when moose season does. "Once the snow starts falling the moose start coming down out of the mountains and congregate in the Anchorage bowl area," he says. "So there tends to be a lot of poaching right here in town."

Some habitual violators have achieved legendary status with the troopers. One hunter had already had two aircraft seized by the troopers when he was spotted in Katmai National Park and Preserve loading a dead moose into his airplane. As a trooper circled overhead, the poacher, who had vowed he'd never let Fish and Wildlife seize another of his aircraft, doused his plane with gas and set it on fire.

—*Elaine de Man*

Update

Grumman's first X-29 ("X-29," April/May 1988) has flown more than 225 missions, breaking the record for test flights by an X-series aircraft. (Of the three X-15s built, one recorded 199 flights by October 1968, after which it was shipped to the National Air and Space Museum.) The second X-29, equipped with a parachute to recover from inadvertent stalls and spins during high-angle-of-attack testing, was shipped from Grumman's Bethpage, New York plant to Edwards Air Force Base in California last October and is scheduled to begin flying in January.

NASA

The launch of the Hubble Space Telescope ("Grounded," June/July 1987), rescheduled a sixth time, is now slated for December 1989. NASA had pushed back the launch to February 1990 to accommodate priority missions, but last October the agency juggled payloads for the December 11 *Discovery* flight and postponed a defense department mission until February 1990.

The first Lear Fan ("The Lear Fan Saga," October/November 1988) has been saved from an ignominious fate by the Museum of Flight in Seattle, Washington. The museum, which had long been eyeing the prototype for display, hastily raised $46,000 to acquire Lear Fan 001 after learning that a holding company was about to turn it over to NASA for destruction testing. It was repainted and put on display November 19.

One of the two Mars orbiters launched from the Baikonur Cosmodrome last July (Soundings, December 1987/January 1988) has lost communication capability and is believed to be tumbling out of control. Phobos 1 lost its antenna lock on Earth due to a command error made on September 2. However, Phobos 2, which carries the surface "hopper," is unaffected and is expected to enter Martian orbit in January.

The crash of Continental Flight 1713 in November 1987 (Groundling's Notebook, August/September 1988) was attributed to the failure of an inexperienced crew to have the DC-9 de-iced a second time during a 27-minute wait for takeoff clearance. The National Transportation Safety Board, which issued its findings on September 28, also faulted Denver air traffic controllers for delaying the flight unnecessarily due to confusion about its location at the airport and dismissed the possibility that wake turbulence from a landing Boeing 767 disrupted Flight 1713's takeoff.

American Rocket Company successfully fired its hybrid rocket motor on September 2, moving AMROC closer to a suborbital flight test ("The California Rocket Race," December 1987/January 1988). AMROC president George Koopman says he anticipates several customers for the 100-mile flight, which will provide about four minutes of microgravity.

The Radio Amateur Satellite Corporation (AMSAT) will deploy a communications satellite from the Soviet space station Mir in late 1989 if the U.S. government approves an export license ("Homemade Satellites," December 1986/January 1987). The SatelLife project, in which a 20-pound satellite will be lofted to provide an electronic mail service to physicians in remote locations around the world, was organized by Soviet space scientist Roald Sagdeev ("The Space Statesman," October/November 1988) and Harvard cardiologist Bernard Lown. AMSAT will construct the "microsat" at a small factory in Boulder, Colorado.

The Pearson Airpark Historical Society opened an aviation museum last November at the Vancouver, Washington airport to commemorate the landing of the 1937 Soviet transpolar flight ("Soviets Blaze Sky Trail over Top of World," December 1987/January 1988). Negotiations are under way with the Soviets, who periodically send entourages to the historic site, to procure Soviet aviation artifacts for display.

Space debris ("Eyes on the Sky," April/May 1987) could be swept up by orbiting dumpsters in the 1990s if NASA approves a prototype ASPOD—Autonomous Space Processor for Orbital Debris—built by a University of Arizona engineer. Kumar Ramochalli, funded by the NASA-backed Space Research Association, built the ASPOD for $20,000 from off-the-shelf hardware. He envisions a fleet of a dozen ASPODs that will roam about space melting debris in solar-powered ovens. The vehicles would then be retrieved by a shuttle or burn up on re-entry.

The theory that homing pigeons use Earth's magnetic field to navigate ("The Birdman of Queens," August/September 1987) got a boost last June when hundreds of birds disappeared during a race from central France to northern England that coincided with a massive solar flare. Such flareups in the sun's magnetic field cause fluctuations in Earth's magnetic field, disrupting radio communications.

A test to detect microbursts with Doppler radar at Denver, Colorado ("The Might of the Microburst, August/September 1986), concluded August 31 and was deemed "highly successful" by the Federal Aviation Administration. Tower controllers at Stapleton Airport warned pilots of 47 microbursts detected within five miles of the airport. Another series of tests will begin in Kansas City next summer.

The FAA ruled in September that wind shear detection equipment be installed within the next four years in all U.S. aircraft with 30 or more seats.

—Patricia Trenner

Anniversaries . . .

NASM

Glenn Curtiss' seaplanes floated the Navy into the aviation age.

1910
December 26 Two 17-year-olds, Harry Bruno and Bernard Mahon of Montclair, New Jersey, fly a glider of their own design. The boys fitted their glider with skis and slid down a steep sheet of ice they created by pouring water down a hill. A large mound of ice at the bottom sent the glider into the air. It sailed 300 yards and landed gently, reported the *New York Times*. Bruno grew up to be an aviation writer and founder of aeronautics clubs.

1911
January 26 Glenn Curtiss adapts the airplane for use by the Navy when he successfully ascends from and lands on water. Aided by an Army and Navy crew at North Island in the San Diego Bay, Curtiss worked throughout the month in boots and a bathing suit as he modified his seaplane no less than 50 times before coming up with a stepped pontoon that did not cling to the water.

1941
December 7 At 7:53 a.m. Japanese aircraft begin a sneak attack on the U.S. Navy base at Pearl Harbor, Hawaii, killing over 2,400 people, sinking or severely damaging 19 vessels, and prompting the United States' entry into World War II.

1944
December 15 On a flight from England to Paris, an airplane carrying band leader and Air Force major Glenn Miller disappears over the English Channel. The Glenn Miller Orchestra, one of the most popular big bands of its time, played to sellout crowds and sold millions of records. In 1942 Miller joined the military and became leader of the U.S. Air Force Band in Europe. No trace of Miller's aircraft, a Noorduyn UC-64A Norseman, was ever found; the Royal Air Force believes that the small craft probably fell prey to bad weather. In 1985 RAF pilot Victor Gregory recounted that he and his crew were jettisoning unused bombs over the English Channel on the day Miller disappeared, when a small airplane entered the area and was forced into the sea by the bombs' concussions. Gregory believes the airplane was Miller's Norseman, but the story remains unconfirmed.

1948
December 9 An Air Force C-47 transport carrying a crew of seven makes a forced landing on a 7,800-foot-high plateau of ice and snow in southern Greenland. Four days later, a B-17 attempting to rescue the stranded men was damaged when it plunged into a snowbank. An Air Force rescue glider landed safely a few days later, but its wheels bogged down in the snow when a low-flying C-54 tried to pull it into the air. The next day the glider, minus its wheels, climbed 50 feet into the air before the tow line snapped; the 10 men aboard were unharmed after it landed on the ice. On Christmas day, yet another glider was marooned. Finally on December 28, a C-47 equipped with skis and jet-assisted-takeoff flew all 12 airmen out.

1956
January 9 The Air Force informs the public of White Cloud, ostensibly a meteorological study of the jet stream employing plastic weather balloons. The actual purpose of the project, known to

NASM

Publicized as a weather study, Moby Dick was actually an espionage operation.

insiders as Moby Dick, was to take reconnaissance photos of the Soviet Union. From January 10 to March 1, the Air Force launched 516 balloons; only 44 were recovered, but they yielded nearly 14,000 images of Soviet and Asian territory. Even though each balloon carried a message in Russian offering a reward for the safe return of the supposed meteorological instruments, the Soviets soon discerned the project's true intent and protested vigorously. Air Force officials maintained their cover story, but Soviet outcry finally put a stop to the launches.

AP/WIDE WORLD PHOTOS

A farewell to hooves: Fort Carson put its pack mules and horses out to pasture.

December 1 The Army announces that it will replace its last combat mule outfit, the Fourth Field Artillery Battalion at Fort Carson, Colorado, with a helicopter unit. Mules, used by foot soldiers since before the Civil War, were prized for their ability to carry heavy loads over rough terrain. Thirty-eight helicopters stationed at Fort Sill, Oklahoma, replaced the Fourth Battalion's 125 mules and horses, which were assigned non-combat duties.

1970

December 21 Grumman's F-14A Tomcat, developed as a multi-purpose, carrier-based jet fighter to replace the Navy's aging fleet of F-4s, makes its first flight. On December 30 the prototype crashed when both flight control systems failed. Congress was ambivalent about the need for the airplane, but when pilots at San Diego's Miramar Naval Air Station tested the Tomcat a year after its debut, they raved about its performance. "What counts in a dogfight is climb, turning radius, and acceleration. You haven't got them, you're dogmeat. The F-14 has 'em," one pilot told the *New York Times*. Today, the majority of carrier-based fighters are F-14s and the Navy plans to expand the fleet in 1990.

NASM

Grumman's F-14 Tomcat is the Navy's workhorse for fleet air defense.

1973

December Comet Kohoutek whips up comet mania in the United States. Discovered in March by a Czech astronomer, Kohoutek was to be the celestial display of the century. Anticipation of the comet's appearance spawned sales of telescopes, binoculars, and astronomy books, as well as comet T-shirts, a quickie paperback, and luxury comet-viewing cruises aboard the *Queen Elizabeth II*. In the *New York Times*, William Safire predicted a "spurt of sales in Comet cleanser, with concomitant headaches for the House of Ajax." Some religious groups saw the comet as a warning of Judgment Day and urged Americans to leave the country before January 31. When Kohoutek appeared, it was less than dazzling: even in rural areas, where night skies are darkest, the comet was no brighter than Jupiter. Kohoutek redeemed itself by providing a flood of scientific data, much of it gathered by astronauts aboard Skylab.

1978

January 13 NASA selects six women to participate in its two-year space shuttle astronaut training program. One of the six, Sally Ride, became the first American woman in space.

NASA

The space shuttle propelled the first American women into space.

1987

December 29 Soviet cosmonaut Yuri Romanenko returns to Earth in good health after setting a space endurance record of 326 days aboard the space station Mir.

. . . and Events

November 26–December 25
"Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Great Plains Black Museum, Omaha, NE, (402) 345-2212.

December 12
Highest frequency of the Geminid meteors, from 11 p.m. to 5 a.m.*

December 21
Solstice occurs at 10:28 a.m. EST, marking the beginning of winter in the northern hemisphere.*

December 24–January 22
"Steichen and His Men: A Photographic Portrait of World War II," Smithsonian Traveling Exhibition. At Alabama Space and Rocket Center, Huntsville, AL, (205) 837-3400.

December 31–February 12
"Exploring Microspace," Smithsonian Traveling Exhibition. At Children's Museum of Wichita, Wichita, KS, (316) 267-2281.

January 8–12
National Meeting of American Astronomical Society. Lectures on paleoclimatology, the inflationary universe, the history of the galaxy, and radio astronomy. At Boston Marriott Copley Place, Boston, MA, (202) 328-2010.

January 14–February 12
"Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Montgomery County Historical Society, Dayton, OH, (513) 228-6271.

February 22–25
"Highlights of Aviation History." Topics include the Golden Age of Flight, women in aviation, the flying wing, and the stealth bomber. At The Broadmoor Hotel, Colorado Springs, CO. Smithsonian National Associates, (202) 357-1350.

**Call the Smithsonian's Earth and Space report at (202) 357-2000 for recorded information on astronomical events.*

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *National Air and Space Museum, Washington, DC, 20560. Events will be listed as space allows.*

—Diane Tedeschi

Cultural Exchange With a Return

MARK AVINO/NASM

Artifacts in director Harwit's hands, the fei pan *became works of art in Dai's (far left).*

One morning last September, under the benign wings of the Douglas DC-3 in the Museum's Hall of Air Transportation, Chinese juggler Dai Shucheng presented the Museum with two tools of his trade. With the exaggerated gestures of a stage performer, he pointed at the fragile pine-and-linden boomerangs in Museum director Martin Harwit's hands and spoke earnestly in Mandarin. "The Chinese regard these *fei pan* as works of art," translated Dai Xing, the young Third Secretary for Cultural Affairs from the Embassy of the People's Republic. "I had to receive permission from the Ministry of Culture to give them away. This is the first time that *fei pan* have been presented outside China."

Dressed in a fringed costume of green and gold with a red dragon and sequins on his chest and a matching hat, Dai Shucheng selected a six-armed pinwheel boomerang from an array on a nearby table. Over the next 10 minutes, he demonstrated why the Chinese consider boomerangs art and Dai a national treasure. His performance was part of a tour by The Incredible Acrobats of China, who performed at state fairs throughout the country in the summer and early fall.

Grinning with mischief, he hurled the pinwheel just over the heads of the small assembly watching, his grin broadening as several in the group ducked. He caught it lightly by a pin sticking downward from the center (so it could be caught spinning) and held it high, in the circus tradition, to show either that the stunt was over or that the boomerang had drawn no blood.

He hurled the next boomerang straight at the crowd at about chest level. The collective inhalation of breath was released as laughter when the boomerang turned sharply and spun back to Dai. Those aware that the boomerang is the peaceful descendant of a Stone Age weapon, the throw stick, may have had good reason to be nervous. In his book *Many Happy Returns,* boomerang expert Ben Ruhe writes, "The throw stick . . . found in ancient Egypt, South India, North Africa, prehistoric Europe . . . and among the pre-Columbian ancestors of the Hopi . . . takes effect by stunning, breaking bones, and maiming, though on occasion it may cut like a knife or pierce like an arrow." Throw sticks are curved but non-returnable; the returning boomerang seems to have no better use than fun, or art.

Most of the boomerangs in the Museum's collection, to which the Chinese *fei pan* will be added, are Australian aboriginal artifacts. The native Australians are generally credited with the invention of the toy, but Dai claims it has a Mongolian origin.

Dai snapped two boomerangs at once, and they spun away in opposite directions, fluttering like doves leaving the hands of a magician. He threw a crescent-shaped boomerang that returned to halve the stem of a flower sprouting from his hat. Then he launched one, two, three boomerangs and caught them in succession. He repeated the stunt with four and attempted five, but gentle drafts pushed the lightweight pinwheels too close to the floor for the wizard to catch them all in time. No one was as disappointed as Dai, who did what any aeronautical engineer would do under similar circumstances: increase power. Finally, he put enough force in his throw and caught number five with a gleeful little "Hoo!" that required no translation.

—Linda Shiner

Body Double

Though the Hubble Space Telescope is still awaiting launch, the Museum is already taking steps to immortalize the enormous instrument. The telescope is to be launched by the shuttle in December 1989, some three and a half years behind schedule. Meanwhile, a full-size version is being restored at the Museum's Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland. The model is expected to go on exhibit in the Museum's Space Hall late next summer.

More properly known as the Hubble Space Telescope/Structural Dynamic Test Vehicle, the engineering prototype was built to assess the telescope's ability to endure the stresses of the launch. Constructed and used by the Lockheed

Missiles and Space Company to run flight tests without the expense of constructing a full prototype, it was also used to teach ground crews how to handle the cumbersome yet delicate object. "They took the structural and dynamic test vehicle and they dressed it up to look like the flight spacecraft," says Joseph Tatarewicz, an associate curator for space science and exploration. "And they then exercised all the ground handling that they were going to do with it—they attached cables to it, they hoisted it up, they took it from a horizontal to a vertical position, they moved it with cranes, they moved it from one building to another—to find out what the problems were in handling a vehicle of that size." Finally, the test vehicle was disassembled and used as a model for fitting the harnesses that make up the 25,500 miles of wire in the telescope's electrical system. Use of the test vehicle began in 1972 and was largely finished by 1980 with the completion of the harnesses.

The test vehicle differs from the actual telescope in several important ways. It does not, of course, contain the telescope's expensive optics and electronics, which partly accounts for the differences in weight: 25,500 pounds for the spacecraft versus 3,649 pounds for the test vehicle. When it was undergoing testing, "mass simulators" were bolted inside the vehicle to duplicate the telescope's exact weight and center of gravity. And only the forward one-fourth of the test vehicle is covered

LOCKHEED MISSILES AND SPACE COMPANY

The space telescope's stand-in at work.

with shiny, protective multilayer insulation, in keeping with the 1976 version of the telescope; later calculations revealed that the entire instrument would have to be covered with a thermal blanket for temperature control in space.

CAROLINE SHEEN

Back to the Future

If you couldn't be in Florida on September 29, the Museum's Space Hall was an appropriate alternative. At 11:38 a.m., when the space shuttle *Discovery* lifted off its pad at Kennedy Space Center, an anxious crowd was watching on a large-screen video monitor at the Museum. Another crowd gathered four days later (above) to cheer and applaud when *Discovery*'s landing gear touched down on the dry lakebed at California's Edwards Air Force Base. Two and a half years after the *Challenger* accident, the title of the IMAX film playing in the Museum's Langley Theater summed up the enthusiastic reaction to STS-26: the dream *is* alive.

Of the features the model does share with the telescope, at least one was unintended. "This project—the test vehicle restoration project and our getting the test vehicle and all that sort of thing—that's been going on for over five years," says Tatarewicz. "It's basically been my career since I've been at the Museum. In the last five years the launch date of the Hubble Space Telescope has changed a dozen times. And over the last five years the scheduled exhibition dates have changed a dozen times."

But now that the shuttle is flying again, things are looking up for the Hubble Space Telescope. And they are looking brighter—literally—for the test vehicle. Museum technician Anne McCombs, who has been involved with the project since shortly after joining the Garber Facility staff last March, has been painstakingly scouring the artifact with Scotch-Brite cloths to rid it of corrosion. "Seems like there's miles of it," she laughs. It *is* large. Some 42 feet long and 14 feet wide at its widest point, it's about the size of a railroad tank car.

Lockheed unwittingly made the restoration experts' job a little easier. For several years the test vehicle was stored outdoors. Then, in 1986, the company donated the artifact to the Museum and hauled it to the Garber Facility from its Sunnyvale, California base aboard a flatbed trailer. "It's good they shipped it in an open trailer," Tatarewicz says. "That helped blow all the birds' nests out of it."

—Karen Jensen

Cream of the Crop

"Do not open in the museum!" warns the shiny silver wrapper. Only when they leave may visitors sample the best selling item in the National Air and Space Museum's gift shop: freeze-dried ice cream.

Dehydrated to two percent moisture and sealed in polyester foil pouches, the five-eighths-ounce bars of chocolate, vanilla, and strawberry ice cream are ready to eat at room temperature. During the summer months, tourists consume the unusual confection at a rate of 18,000 bars a week.

What makes the $1.50 snack so popular? Aside from its novelty, the ice cream is similar to a dehydrated treat developed for the Apollo space program. Says Samuel J. Greenberg, director of Smithsonian museum shops, "I think it captures people's imagination that they can eat the same food that the astronauts did."

Unlike Museum shoppers, Apollo astronauts were apparently not much taken with the idea. According to Charles Bourland, manager of space station foods at Johnson Space Center, freeze-dried ice cream was available to all Apollo astronauts but only those of Apollo 7 chose to include it on their 1968 mission. Twenty years later, neither Walter Cunningham nor Walter Schirra can remember having eaten it (the third crew member, Donn Eisele, died a year ago). "It wasn't popular," Bourland says.

Conventional ice cream, of course, was. But Skylab was the only U.S. spacecraft equipped with a food freezer, enabling appreciative astronauts to consume the dessert in its usual state. For the Apollo missions, most foods came in the form of dried cubes—from strawberries and cornflakes to beef sandwiches and cinnamon toast. Astronauts would place the cubes in their mouths and wait until the food was soft enough to chew.

The freeze-dried ice cream cubes were developed by dairy technologists at the U.S. Army Natick Laboratories in Massachusetts. Natick's food technologists designed most of the foods used in the space program

in the 1960s. When NASA approved of a prototype, it would award production contracts to commercial food companies.

Natick production literature describes the concoction as an "ice cream mix, freeze dehydrated into cubes for use in aerospace feeding." The guide instructed potential manufacturers to heat the ice cream formula for 30 minutes at 165 degrees Fahrenheit. After it cooled, the homogenized liquid was poured into shallow trays and loaded into a blast freezer. Technicians then moved the trays into a vacuum drying chamber, where the ice cream stayed frozen as its water content

changed from a solid to a gas without passing through a liquid state—a process known as sublimation.

The freeze-dried sheets were then ground to a powder at room temperature and compressed into bite-size cubes by a Stokes pill presser. After the cubes were coated with a gelatin mixture (to prevent crumbs from breaking off and floating around the space capsule), they were redried and finally packaged.

In retrospect, all of this tedious and expensive processing may seem excessive considering that off-the-shelf items such as cans of pudding, granola bars, Vienna sausages, tuna, trail mix, and fresh fruit are routinely sent aboard the space shuttle. But food technologists, concerned about microorganisms in space food, proceeded with caution. "We didn't want anybody getting sick up in space and saying 'Hey, the food was no good,' " says Norm Harris, a food technologist at Natick who holds the patent for the ice cream's gelatin coating.

Three companies now meet the Smithsonian's demand for this

unconventional snack. The companies also sell the ice cream under their own labels to other museums, planetariums, space centers, and camping supply companies. Although they use the same sublimation process as Natick did for its prototype, the ice cream does not undergo as many production stages.

Innovative Foods in San Francisco slices its ice cream into single servings, readying it for packaging when it comes out of the freeze-drier. And unlike the astronauts' cubes, the half-inch-thick slabs are uncompressed and uncoated.

As long as curious visitors continue to take a packet or two home, the ice cream should maintain its lofty sales record. But for some, it is more than a novelty. For two years now, according to assistant shop manager Debbie Galliher, a man from the embassy of Brunei has been coming to the gift shop periodically and purchasing one to six cases of ice cream, at 225 bars a case. No one is sure what happens to all of this ice cream, but gift shop staffers believe that the royal family of Brunei has a sweet tooth for space food.

—Diane Tedeschi

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

"Out of This World" Cartoon Classics Series Cartoon characters and comic movie greats fearlessly take to the skies, explore outer space, and battle extra-terrestrials. Langley Theater, January 14 and 28, 9:30 a.m.

"Computer Generation" Film Series Space fiction films (titles to be announced). January 6, 13, and 27 and February 3, 10, 17, and 24. Langley Theater, 7:30 p.m.

December 1 General Electric Aviation Lecture: "The Schneider Trophy." Air Vice Marshal Ron Dick, RAF (Ret.). Langley Theater, 7:30 p.m.

December 3 Monthly Sky Lecture: "Galaxies, Galaxies Everywhere (And Not One To Be Seen)." Robert Smith, NASM. Einstein Planetarium, 9:30 a.m.

December 14 Aerospace Lecture: "Countdown." Former astronaut Frank Borman. Langley Theater, 7:30 p.m.

December 15 "Cold War" Aviation Film Series: *A Gathering of Eagles* (1962). Langley Theater, 7:30 p.m.

December 17 Wright Brothers Symposium: "Eighty-five Years After Kitty Hawk," a review of Orville and Wilbur's lives and careers. Langley Theater, 9 a.m. to noon.

January 7 Monthly Sky Lecture: "Who's a Qualified Observer?" Michael Dennis, NASM, Einstein Planetarium, 9:30 a.m.

January 12 General Electric Aviation Lecture: "The Dawn of Asian Aviation." Kurt Weil, pioneer of airline routes in Asia. Langley Theater, 7:30 p.m.

January 26 Wernher von Braun Memorial Lecture: "Mission to Planet Earth." John L. McLucas, Questech, Inc. Langley Theater, 8 p.m.

April on Ice

Resolute Bay
Northwest Territories
Canada
4 April 1948

Dearest Prissy,

Today is Sunday, but it doesn't mean anything here. We are working very hard and look forward to returning. The cooks are doing a good job with what there is to work with.

We flew over to Isachsen yesterday and were lucky. The C-47 landed and placed the weather people on the snow-covered plain. We flew top cover in a C-54 and circled the area to make sure everything was okay. Two hours later the crew on the ground had marked a runway on the bay ice with red flags, so in we came. It was quite smooth and we rolled to a stop just short of the weather people's tent, which they had already erected. The beginning of a new settlement.

By 1947 the United States and Canada, increasingly aware of the strategic importance of the area above the Arctic Circle as well as the need to provide accurate weather reports for burgeoning intercontinental airlines, had begun to establish a network of stations on the Queen Elizabeth Islands, the northernmost islands stretching into the Arctic Ocean. The first weather station was located at Eureka Sound on Ellesmere Island, and another followed at Resolute Bay on Cornwallis Island. Four hundred tons of supplies were brought by ship to Resolute, from which they would be delivered to two more stations to be established the next year.

About this time I reported in from China to the 11th Air Transport Squadron at Westover Air Force Base in Massachusetts, where my wife and I settled into a nearby apartment. My squadron drew the assignment of airlifting the supplies cached at Resolute Bay, along with teams of weathermen, within a 30-day period—the month of April. We would be using five C-54s, one C-47 equipped with skis, and a C-82 for hauling bulk cargo.

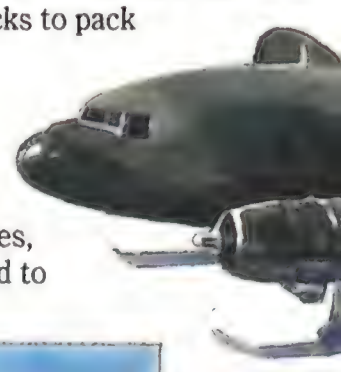
Flying on the edge of the North Pole didn't prove to be anything like flying C-54s over "the Hump," the Himalayan route between China, Burma, and India during World War II.

By April we had moved into Resolute and were ready to begin flying off a freshwater lake covered with six feet of ice. We picked two islands, Prince Patrick and Ellef Ringnes, as potential sites. On our initial flight into Ellef Ringnes, 275 miles northwest of Resolute, crew members found a promising site, marked as Isachsen in the Deer Bay area on our map.

Upon our return to Resolute, a Royal Canadian Mounted Policeman and two Inuit Indians mushed into camp on dog sleds. They had killed 12 polar bears during their month on the trail, and the sleds were piled high with the skins. After dinner, some of us watched them skin their last kill, a formidable-looking male. Since it had been shot close by, we found the hunters' assurances that polar bears were unlikely to visit the camp at this time of year less than comforting. Kitchen details were instructed to hand-feed "Kitty," their pet white fox, and make sure that no food was left outside.

The next day our search for a good site on Prince Patrick proved more hazardous. After flying over the island for some time, its landscape nearly obliterated by snow and ice, we spotted a mile-long frozen lake. Forsaking our usual procedure, the C-54 landed first.

A mistake. The snow was far deeper than anticipated, and the ice was ridged with small hummocks. The airplane roared to a quick halt. The landing gear was undamaged—a miracle—but we had to search for another site. Before we could take off, however, we had to taxi back and forth in the landing tracks to pack down the snow. By applying the brakes, running the engines to maximum speed, then releasing the brakes, we gained enough speed to



wobble into the air.

We next flew to a cove on the island's east coast, marked on our map as Mould Bay, and this time the C-47 landed first. Everything went as planned and the second station was soon under way.

Back at Resolute, our team was now up to full strength—80 men—and the airlift of supplies into the two new stations accelerated.

9 April 1948

My Dear Prissy,

I'm very tired so will write you a very short note.

You should see the whiskers on my upper lip. Ronald Coleman has nothing on this set.

Intended to take my camera to Isachsen today, but forgot the thing. We were within 600 miles of the North Pole at noon.

We are working quite hard and doing about everything. You should see me juggle these 100 lb. boxes.

Do you have any news for me? There hasn't been any mail from the states, nor have we had a ship out of this place yet.

Our little huts are almost covered with snow. They are also very crowded.

The airlift was in high gear when a "willawaw" hit. Winds gusting up to 50 mph lashed the base, churning the snow like great balls of cotton and making it almost impossible to see from one building to another. Work was halted for two days. Our huts, never impervious to cold, weren't much better at keeping out snow, which formed little cones on the floor. The snow's invasion added to our sense of discomfort as we huddled on cots in sleeping bags zippered to the nose, half dozing, giving abused muscles a brief respite.

Temperatures sometimes dropped to –50 degrees Fahrenheit, with a wind chill factor making it more like –80 degrees. Frostbite was a constant threat; we spent a lot of time massaging our ears and noses. Our latrines, contrived of wooden packing crates and burlap, became retreats of last resort.

We grew leaner as the airlift progressed, and icicles forming on face masks added to our disreputable appearance. Any illusions of a glamorous polar expedition had dissipated.

ILLUSTRATIONS BY PAUL SALMON

Keeping the aircraft running was a major concern. Each morning at four, maintenance crews placed heater ducts in each engine and fuselage. After four hours the oil and hydraulic fluid were warm enough to allow us to start the engines. From then on we shut them down only briefly during the day.

12 April 1948

Dear Prissy,

It is now 11:30 p.m. and isn't dark yet. In one more week there won't be any nighttime in the Arctic.

Your letter arrived today and it was good to have a talk with you.

I checked a crew into Isachsen today and it was a beautiful day. On the return trip we dropped down to 500 feet over Cornwallis Island and saw some musk ox.

We are working quite hard and hope to finish by the last of April. I'm glad you have the drapes, and hope they were what you wanted.

I certainly envy you in the springtime weather down south. Our temperature is now about fifteen below and we are expecting the flowers to bloom soon.

Navigation here sometimes proved uncertain, even dangerous. The magnetic north pole was located about halfway between Resolute and the islands, so our compasses went crazy when we passed over. The radio beacons at the stations were so weak that their signals could only be picked up at close range. We often had to navigate by using a sextant to shoot sun lines, but dense fog frequently blocked the sun. It was easy to lose your sense of direction.

On one trip we overshot Isachsen and flew out over the Arctic Sea. The incredible flatness spreading to the edge of the horizon eventually confirmed that we had

left land behind. We retraced our route for 20 minutes before spotting another aircraft circling over the island site.

17 April 1948

Dear Mama,

From your last letter I believe that will be your name soon.

There won't be much to tell you tonight except that we have been very busy. I have about all of my clothes dirty and we have no facilities for washing clothes or the body.

There's only one trip left into Isachsen. We completed eighteen into Patrick and have ten more to do. With four planes we have made six trips each day, hauling about 35 tons per day. Five more good days would complete our operations here. I expect to be home before much longer.

If I wasn't so tired I'd write more but my old muscles just ache tonight.

Our pace of operations increased. In the mess hut, two mammoth pot-bellied stoves, each fitted with a tank for melting ice for water, were in use almost constantly. Cooks ladled out powdered eggs, grits, steaks, Spam, and bacon from 5 a.m. to midnight.

On one run to Prince Patrick we spotted two large herds of caribou about 20 miles apart, streaming in long lines across the sea ice, bulls with antlers laid back, calves straggling behind. There were still no signs of polar bears near camp, but our crews spotted one from time to time loping over the sea ice between islands.

Then we got word: more work! We'd been asked to carry mail and some badly needed supplies to the weather station at Eureka Sound on Ellesmere Island.

23 April 1948

Dear Prissy,

Prince Patrick is now complete, Isachsen will be completed today, and we have three planes operating into Eureka Sound, the most northern station. The big job is over and loading airplanes until midnight is now only a memory.

On some days our runway has looked like Washington National Airport. Our last ship returned at 10:30 last night—but it really isn't night anymore, as you can read a newspaper.

How's the family? I can just see you in a few months.

Fairbanks is only one thousand miles from our present location. Maybe we should run over there and see the place. The North Pole looks like a barber pole and sets just upon a hill north of our radio shack. (Believe that?)

I'm on the radio this morning and the planes are taking off, so bye for now.

On the morning of April 25 I made the last trip into Eureka Sound. We flew almost due north until we saw a deep valley flanked by the island's rugged mountains, the Princess Margaret Chain, then followed the valley until we picked up the radio beacon and spotted the camp. In the strong winds and extreme cold we lost no time unloading the cargo. We cut only the two engines on the left side, dumped the supplies, and were off within the hour.

It was a magnificently clear day, with the snow reflecting the hue of the sky. As we droned over the landscape, a crew member thought he saw movement, a streak of silver-gray. Dropping down to 500 feet we glimpsed a small pack of Arctic wolves, a rare sight, trotting across the snow.

By the time we reached Resolute all the aircraft had departed for Westover. When I touched down, the remaining personnel, luggage stacked, were waiting to scramble aboard. "Operation Resolute Bay" had been completed five days early.

—Henry R. Johnston, Colonel, U.S. Air Force (Ret.)

Type Caste

The movie producer ordered champagne, then leaned across the table. "There's something I have to know," he said.

He had just bought the movie rights to my first novel, *Somewhere off the Coast of Maine,* and had brought me to this chic restaurant in a limousine. I was beginning to feel accomplished and professional, like a successful writer. "What was it really like?" he asked.

Surely, I thought, he meant the experience of writing a novel: plot twists, character development, dramatic structure.

"What was being a stewardess *really* like?" he said.

The biography on my book jacket included the fact that I had worked as a stewardess for seven years. Now that I was an ex-flight attendant, callers from magazines, newspapers, and TV shows all asked the same question: *What was it like?*

After graduating from college in 1978, I led a double life. At night I donned a TWA flight attendant uniform, parked at Kennedy Airport, and worked my way to cities like Athens and Cairo. I did safety demonstrations, pointing out emergency exits and oxygen systems on 707s, 727s, DC-9s, 747s, and L-1011s. I served drinks and dinner to several hundred passengers at a time. I lifted heavy suitcases, learned how to balance trays in turbulence, treated bloody noses and airsick passengers, offered travel tips, and smiled a lot.

By day I wrote a novel. Alone in my apartment, I ate Chinese takeout at the typewriter and struggled to tell my characters' stories. I kept silent about my efforts—after all, I had only a few notebooks full of ideas and some badly typed pages to show for it. To the people I faced each night, I was a stewardess. To most, that meant I was a glorified waitress and the stereotypical dumb blonde.

"Don't tell anyone what you do for a living," my cousin once whispered to me at a party. "It's—embarrassing."

Men either recoiled at the words "flight attendant" or turned lascivious. The assumption was that I had a fast lifestyle, a man in every port, and a brain the size of a pea. During one flight, I noticed a passenger engrossed in a novel I had just read. "Isn't that a wonderful book?" I asked. He looked up in total surprise. "You *read?*"

Women would say coldly, "Must be the most boring job in the world. Pure drudgery." "It *is* hard work," I'd say, "but it's fun, too. Like last night . . . " I'd start to relate how I had caught a glimpse of the Eiffel Tower through a cabin window and felt as though I had the greatest job in the world. But before I could finish, my listener would have turned away.

Once I stopped flying, everyone listened—radio and TV talk show hosts, friends, and strangers. Overnight, I went from embarrassing to interesting. Not only was everyone fascinated by my former job, they also figured I was some kind of investigative journalist working as a stewardess strictly to observe the lifestyle, like Gloria Steinem going undercover as a Playboy bunny. "How did it feel," someone asked, "to be working with all those—stewardesses?"

"It felt fine," I said. "I mean, I was a stewardess too."

"I know that," she said. "But you weren't really."

"Yes," I told her, "really."

"How did you do it?" asked one man sympathetically. "I wanted to do it," I insisted. "I liked it." I told them how at age 12 I had read about being an "air hostess" and decided that was the job for me. I longed to travel, meet people, and have adventures. But my guidance counselor told me, "Ann, smart girls don't become stewardesses." My new audience agreed.

"But they do," I explained. Then I would launch into anecdotes about the men and women lawyers, actors, opera singers, scholars, and entrepreneurs who worked as flight attendants.

Just before my book was published and while I was still flying, a friend invited me to join him and another couple for dinner. "You have to excuse me," I said when I arrived at the pizza house. "I just got back from London and I'm a little jet-lagged."

"Ann's a stewardess," my friend explained.

The woman's eyes glazed over as she stared down her nose at me. "How interesting," she said flatly.

From then on, whenever she spoke to me—which wasn't often—she did so slowly, in monosyllables. Until my friend mentioned my novel.

"Novel?" she said. "You wrote a novel?"

"Yes," I said, "it'll be out next month. It's about these three women . . . "

"Tell me," she said, grabbing my arm. "What's it *really* like being a stewardess?"

—Ann Hood

OUR LONDON
TERMINALS
ARE DESIGNED
ON THE SAME
PRINCIPLES.

You'll take off as soon as you land with British Airways. Because we built the same swift, efficient service into our Gatwick and Heathrow terminals as into our Concorde. It's what you'd expect from the world's favourite airline. Whether you're on the ground or in the air, we'll fly you to your destination.

BRITISH AIRWAYS
The world's favourite airline.

A Border Patrol pilot flying a Cessna 182 checks out a van near the border at Nogales, Arizona.

Holding the Line

If rules are made to be broken, then borders are there to be crossed.

by George C. Larson

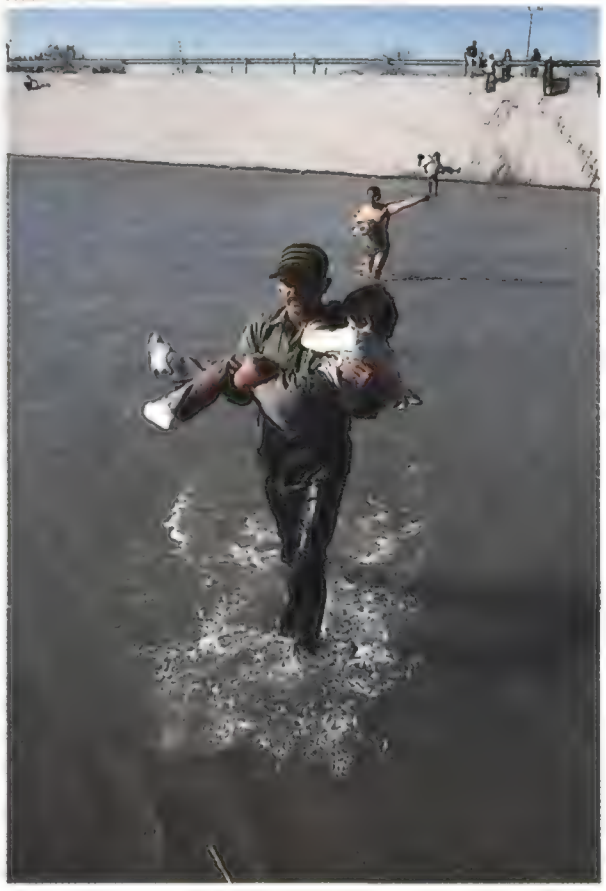
Photographs by Baron Wolman

You can't see John D. Pool, but he can see you. Pool is the pilot of the helicopter circling not more than 20 feet above your head while you stand, miserable, in a waist-deep tidal pool in Imperial Beach, California. As he circles, Pool points his quad-mount illuminator at you, and in the glare of four 310,000-candlepower spotlights, you hear but cannot see the Hughes OH-6A he's flying.

Stone and iron markers line the U.S.-Mexican border from El Paso, Texas, to the Pacific Ocean.

A pilot spotted this group in brush north of Tijuana, then directed the ground units that moved in (top).

PAUL CONKLIN



During much of the year, the Rio Grande offers so many shallow fords that it's just a stroll across . . .

Pool does not need to utter a word through the loudspeaker mounted in the helicopter's belly. He does not need to land and ask you for identification. He knows what your problem is: you have arrived in California without passing through the official Port of Entry at San Ysidro, a couple of miles away. You are an illegal alien—in the shorthand of the pros, an "illegal," a "wet." He knows that the screaming turboshaft engine and the blast of downwash from the rotor blades above you will prove overwhelmingly intimidating. So you stand in the water, dumbfounded, squinting up at the light.

But you know just what to do as if you had practiced it. You and your three companions turn and begin wading back through the cold water, back the way you came. Back toward Mexico.

Like most Border Patrol agents, Pool views his job with a certain detachment and, at moments, reveals an appreciation for its ironies. The Border Patrol is a division of the Immigration and Naturalization Service under the Department of Justice. Where the Customs Service, part of the Department of the Treasury, has jurisdiction over goods

Agents say they rarely had to use weapons before, but increased drug traffic has brought violence.

crossing into the United States, the Border Patrol has the responsibility for people. The Patrol enforces laws with social and political ramifications that make the job different from that of most law enforcement officers. Immigration laws bend a little more often with the political winds, and the agents must live with that. The Immigration Reform and Control Act of 1986, known for its most important effect—amnesty—was the most recent gale.

If the United States wanted to close its borders, it clearly has the wherewithal to do it. There seems to be a tacit understanding among agents that their task has been purposely—and perversely—fashioned in such a way as to be futile. This conviction is woven into their language and expressed in a certain tone. But most agents mellow with time and with the gradual realization that the throngs who toss themselves like waves at the U.S. border do so out of despair.

One Census Bureau estimate says that in 1986 alone, 160,000 people entered the United States illegally and managed to remain. Karen Hess, a Border Patrol program analyst who deals with such statistics, says the figures are controversial but adds, "That's as good an estimate as anyone else [has made]." Some studies say as many as 12 million illegals are permanent residents. Hess says they used to come alone; now they're more likely to bring their families. Most are not coming over with any criminal intent. They want to work and earn money, something they can't do back home. John Pool and his helicopter are there to ensure they don't take a job away from a U.S. citizen.

It wasn't difficult for Pool to find the tracks in the soft sand along the beach.

In the pale light of a dying sunset, footprints are as easy to read as words on a page. And he's been to this spot every night at about this time since he began flying the night shift for the Border Patrol's San Diego sector.

So why doesn't his quarry wise up and find a less obvious place to cross? Because illegal aliens play the odds. At least once in any conversation most agents will describe the job as "a game." This group will probably try again tonight. Pool can't stick around. He will have to return sometime to refuel. He may get a call from a harried ground unit. Or he might be at the eastern end of the sector, 66 miles away. For these four below him, that's time enough, and the time will come. They know this. Pool knows this.

Every San Diego agent knows the dimensions of his nightly defeats. The evidence of thousands of crossings is plain by day. Paths six feet wide have been carved by running feet in the greenery that lines the freeways. In Southern California, the flood of humanity during the dry season has eroded the soil in a pattern that resembles the effect of water. The rusty hulks of cars and trucks, wrecked in crashes through the border fence, pile up in the canyons. As far as a mile north of the border, torn chain-link fences mark crossing points at highways, truck parks, and backyards. As you drive the freeway in these parts at night, the flicker in your headlights is not a cloud of insects, as you first imagine, but the flash of dozens of white running shoes. And once the runners have made it this far, the Border Patrol has little chance of catching them.

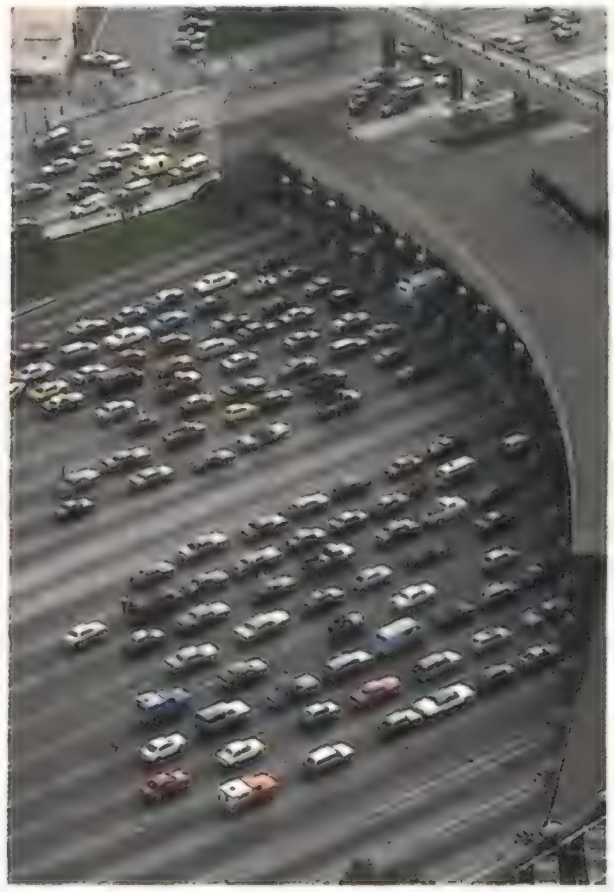
So the agents concentrate their efforts within a few hundred yards of the border, and the heaviest activity is confined to a 12-mile stretch beginning at the coast, winding through the urban maze of Tijuana, and ending near the foothills of the Otay Mountains. Some routes are dragged nightly, the way ground crews smooth an infield, to make it easier to spot fresh tracks and establish when they were made. Along the river in downtown El Paso, television cameras pan the fleet of rubber rafts that carry illegals across for 50 cents a head. One entrepreneur has a ladder over a wall erected to prevent illegal crossing of a railroad bridge. He charges only a quarter.

Few international borders are impervious. The Berlin Wall is an extreme case, but many are completely open, without barriers or markings of any kind. In 1892 the United States set about marking the part of its southern border not defined by the Rio Grande (to Mexicans, it's the Río Bravo del Norte). The markers are simple obelisks of stone or cast iron about six feet tall. Monument number one stands at the intersection of the borders of Mexico, New Mexico, and Texas. It can be found in a storage yard near the huge Asarco smokestack that is easily El Paso's most distinctive feature. Number 258 is just a few yards from the Pacific Ocean. The monuments are spaced according to line of sight: at ground level at each monument, the tops of the adjacent monuments are just visible. Though obviously no Maginot Line, the

PAUL CONKLIN

. . . but imagination and free enterprise will find a way to cross the river's deeper waters.

Most illegal immigrants are sent home as "voluntary returns," but many will keep trying (top).



Ports of entry provide crossing points for the majority of travelers who come and go legally.

Carved by running feet, a maze of trails leads north from Tijuana. Road signs warn U.S. motorists.

Overleaf: Border Patrol pilots see the world from high above the fray. Their grandstand seats make it nearly impossible for anyone to hide.

border is lined by five kinds of electronic sensors to detect vibration, heat, and magnetic disturbances.

In 1987 the San Diego sector alone recorded 500,327 apprehensions, and so far, 1988 data show no letup. The agents point with some pride to the fact that these numbers lead the nation. The ground agents do the hard work of apprehending the illegals, by truck, car, scooter, and even on horseback. Pool and the other 15 pilots based at Brown Field, a small airport near the border, fly around the clock in support. "We're an aerial observation platform, that's all," Pool says.

But observation can take many forms. Only minutes before he'd come upon the four at the beach, Pool had been 10 miles inland following a group of six runners in an arroyo who'd been spotted by a ground unit. When one of the group dived into some scrub—"bushed up,"

Both the pilots and the ground-based agents are expert trackers who see whole stories in footprints.

some agents call it—Pool circled low over the spot and used the rotor wash and external loudspeaker to pin the man in place. Pool's Spanish, like that of all agents, is excellent by requirement: fail the language course during training and you wash out. He spat his words into his helmet mike, and the loudspeaker thundered beneath the floor like the machine gun this helicopter carried when it served the Army. Later, he translated: "I said, 'It will do you no good to hide. Come out of the bushes. The Border Patrol is *everywhere.*'" And he smiled faintly at his hyperbole.

But for the hapless runner, the Border Patrol *had* been everywhere tonight. Within seconds, an agent on a four-wheel all-terrain cycle was peering into the bush, and the runner took off like a calf evading a cowboy. "Yeeee-HAW!" someone yelled over the radio. All six were apprehended, and soon two green and white Patrol trucks arrived to drive the entire group to a detention facility, where they'd be processed for "voluntary return" to the country they were so anxious to leave. For most, it's Mexico, but it could be anywhere. The agent on the ground who made the arrest would get credit for the collar, but Pool would log an assist.

"Fox One, India 12 needs you at the high fence." The radio talk has been sparse and casual tonight, but this call crackles with urgency. A Tijuana police officer is down, shot in the leg. The shooter is described as wearing a red shirt and blue jeans. Pool heels the OH-6A over into a tight turn and pulls up on the collective control in his left hand. The rotor blades pitch upward in response and grab for more air. The little helo vaults out of the arroyo and heads across an open area, a landmark agents call "the soccer field" because the emigrants gathering here to cross used to play while they waited for darkness. Now the smoky fires of makeshift food stands ring the field, setting the humid air aglow. The Hughes snarls overhead through the murk.

Pool approaches a flood control canal. Below, Border Patrol vehicles kick up dust as they race toward a knot of perhaps a hundred people gathering atop the expanse of concrete that parallels the border. The canal is a good hundred yards inside the United States, but the agents generally leave it alone, instead waiting in ambush in vehicles concealed behind fences and buildings some distance away. Now the agents' radio calls are brief, the callers out of breath and apprehensive. And the agents are staying close to their cars as the situation turns unpredictable. Their adversaries could trash a van in a hail of stones, but at least the agents will live through the barrage if they're inside their vehicles.

There. Crawling under a fence that lines a road on the Tijuana side—a red shirt and blue jeans. Pool calls the ground team and immediately enters a slow orbit as the man crosses through automobile traffic, disappears beneath some trees, and emerges in a grandstand beside an athletic field. Red shirt sits down, then stands up. But he never looks to see what's overhead. Pool stays with him as ground agents pass the word to the Tijuana police. Within minutes the suspect is walking, one arm twisted behind him in the firm grasp of a policeman, toward an unmarked sedan parked crazily in the middle of a side street. A ground unit calls Pool: "T.J.P.D. says thanks, Fox One."

Tires lashed together smooth a dirt road so that anyone passing through will leave his mark.

Pool checks his fuel and turns for Brown Field. The first couple of hours of tonight's flying are over. He'll refuel, rest awhile, maybe do some paperwork, then fly another two hours or so before closing up shop and heading home to sleep. So far, tonight has been fairly quiet. "Sometimes the calls come in so heavy you just tell 'em, 'Take a number and wait. I'll get with you when I can.' " But it was on a quiet night like this one that Pool's helicopter took a hit from a stone thrown from the ground. That one primitive missile took out the tail rotor and totaled the helicopter, but he survived. He says it was one time his wife worried about the double risks of flying and law enforcement. But she's gotten used to it, he says. "In a week, I make master pilot," he adds. The step up will mark 12 years as a pilot for the Border Patrol.

When the U.S. Border Patrol was formed in 1924 from about 450 former Texas Rangers, marshals, sheriffs, and cowboys, the agents rode horses. They switched to gasoline power soon afterward and may have tried their first airplane as early as the 1930s. Nobody remembers the airplane, but they know it didn't last. Around World War II they took up flying again with a surplus single-engine Stinson L-5 from the Army.

As an agency of the federal government, the Border Patrol could get all kinds of surplus airplanes, and at one time or another, they seem to have tried anything with wings. The Border Patrol museum in downtown El Paso even has a picture of a Kellett YO-60 autogyro. Richard E. "Hank" Hays, who runs the Border Patrol's air operation today, says he's heard tales about the Kellett. "Those boys who flew the autogyro took the coward's way out and signed up

The new Christen Husky is upgrading the fleet. Its ample wing and flaps are ideal for low and slow flying.

to go to war in the South Pacific," he says—a little Border Patrol joke. The autogyro didn't last either. In fact, the museum's photo collection shows that the early Border Patrol pilots weren't easy on their airplanes. Some of the wrecks depicted in the photographs are no more than a pile of metal tubing and ashes. It is Hays' job to ensure that despite the dangers inherent in flying for the Border Patrol, there are no more photographs like these.

The agents fly because they can't ride a horse or drive a truck through terrain like the ravines outside El Paso at 55 to 60 mph, which is how fast Hays and his pilots fly their Piper Super Cubs and their new Christen Huskys. These light airplanes, with their fat, wide wings, are precisely suited to low speeds. Still, 55 is very slow for any airplane.

They fly low and slow because they are—in tracker lingo—"cutting sign." Sign cutting is the detection of the recent passage of another being through observation of the environment below. You look for footprints.

All Border Patrol pilots start out working on a ground unit and learn sign cutting long before they take to the air. They must have 1,500 hours of flying time and demonstrate competence on instruments. They'll spend their apprenticeship learning the territory over which they fly so well that they know every telephone pole. At night, pilots generally keep a minimum flying height of 200 feet, and although they have a radar altimeter for reference they really depend upon their intimate knowledge of the area. They have to. Once they start flying for real, they'll spend almost all their daylight hours about 15 feet off the ground.

Flying that close to the ground is like surfing. The ocean of the atmosphere pounds against the shoreline of the earth, and invisible currents roil in the wind and the sun's heat. Flying close to a stall, their balance in the airplane must be completely reflexive. Like breathing, you just *do* it.

These are trackers who happen to fly, after all; it's not the other way around. The aircraft is just another conveyance to them. Their gaze is fixed on the ground, and the flight instruments, gauges, controls, and warning lights all have to wait for the rare glance. The pilots' training hones their senses until assessing the airplane's behavior becomes second nature. If an engine runs rough, they'll feel it. If a stall nibbles at a wing, they'll sense it long before any instrument wakes up. All well-trained pilots can fly by the seats of their pants, but the Border Patrol has made it an art form.

As the organization's chief pilot, Hays performs a balancing act. With the press of illegal aliens increasing steadily, his pilots must become more effective. At the same time, they have to fly safely. To be effective, they have to fly low and slow. To be safe, they'd be better off higher and faster. Hays is coping by training his pilots better, buying newer and better airplanes, and adding helicopters to his fleet. He's cross-training his fixed-wing pilots to fly the helicopters, which are so well adapted to this kind of flying.

A study conducted in the mid-1970s showed that most Border Patrol accidents were occurring after a pilot had flown his 100th hour in a given month. The Patrol made 100 hours a month the maximum, and accidents dropped off. Hays says he can recall only one fatality since then, when an agent hit a wire. Most Border Patrol flying is done in light airplanes, which are cheaper to buy and to operate than helicopters. But as Hays introduces more helicopters and pilots trained to fly them, the low-and-slow regime won't be so close to the edge. The helicopters are also better at night, at least when it's clear. At the moment, Hays' only problem is lining up a reliable source for those helicopters after his present source dries up.

The Hughes OH-6A Cayuse, the most plentiful and popular mount in his rotary wing fleet, was developed as a light observation helicopter (LOH, which somehow became the word "Loach") for the U.S. Army and saw its first combat in Vietnam. Hays gets them in what amounts to a permanent loan from the Army as they're retired from service. In Asia, the helicopter carried an electrically driven machine gun with six rotating barrels, but the Border Patrol's OH-6As fly unarmed.

Legends about the Loach abounded, and Army pilots loved it, mostly because its egg-shaped hull had a reputation for saving the crew. It was said that when ordinary helicopters crashed, they sprayed parts the way a lawn sprinkler sprays water, but the little toy-like Hughes would do a polite somersault, shed its rotor blades with no fuss; once it stopped tumbling through the grass, its crew simply unbuckled and stepped out—*ta-dah*. Today's Border Patrol agents pass on the legend, and they believe every word. Hays says that when the National Guard offered him another type of helicopter he said thanks but no thanks. But if the Army goes ahead with its plans to retire the last Loach in the 1990s, he's out of luck.

On an early morning patrol out of El Paso, Hays is in his element. He has a Hughes this morning—and below him, the tracks of four men. Hays knows they are men because of their footprints: one pair of pointy-toed cowboy boots, one pair of combat boots, and two pairs of tennies. If he had to, Hays could categorize the tennis shoes by their imprints: fish scale, ball bearing, diamond circle, running W. Such precise classification of footgear is important, he explains: "Say I've got a group of five—four tennies and one huarache [sandals made from tires]. If I get the four tennies, I know I've got to find the guy with huaraches."

He flies along at a semi-hover in silence for a while. "These guys are lazy. They're just following the road," he says after a mile or so. "They'll make

The Army-loaned Hughes OH-6A takes agents into rugged country where even horses fear to tread.

about three, four miles an hour walking through here." The helicopter heels hard right as he circles tightly—he's momentarily lost one of the four tracks. "There he is." Hays has the trail again and resumes his course. The airspeed is too low for the indicator to be reliable, and the needle dances on its peg. He flies twisted slightly to the right, head down, looking at the ground, his hands and feet working the controls instinctively. "There are rabbit and bug tracks over these, so they're not fresh. These guys came through last night."

Hays knows where the four prints below him are bound: the railroad. The OH-6A tops a slight rise, and suddenly shiny rails appear, extending east and west. The prints lead to a soft sandy area along a grade where the trains often slow down. There are no footprints leading away. The four are long gone.

These days there's a change in the weather, and every Border Patrol agent knows it. They used to brag about never having to use their sidearms—the game was basically free of violence. But recently aliens have been raped, robbed, and murdered as they tried to cross certain canyons in the dark, so the San Diego sector has formed a special detail to cope with the problem. "Their job is to *protect* the aliens!" one agent snorts, incredulous. El Paso has a problem with violent gangs that have set up shop just beneath the outstretched arms of "Cristo Rey," a statue of Christ that stands atop a mountain and overlooks the city.

Narcotics traffic is also up. The Border Patrol doesn't really go looking for it—it just comes to them. According to Dennis McCloskey, a deputy chief at the agency's headquarters in Washington, "Along the southern land border, the Border Patrol confiscates 60 percent of the marijuana and 40 percent of the cocaine of the total amount impounded." That's more than any other law enforcement agency. Hays says agents are being forced to upgrade their weapons, and some patterns are emerging: "Cocaine people are generally wealthier, more established," he says. "It's the marijuana smuggler who's new, just getting started. He's more desperate. He's got nothing to lose. He's the one who's dangerous."

As Hays patrolled El Paso and worried about how to get his radios fixed and a dozen other things chief pilots have to bother with, and as John Pool saddled up for another four hours of flying, they could look forward to a big hire that would soon add 1,350 agents to the force. More than 30 of the new hires will become pilots. Many times that number will apply, but some will flunk the written exam, and the oral will filter out the "Rambos," as Hays calls the more gung-ho candidates.

And the agents are getting help. At the end of September Hays was ready to solicit bids for more aircraft, some of which he may send north, where there are growing problems on the remote parts of the Canadian border. McCloskey says the Border Patrol is establishing new air bases in Montana and North Dakota. Agents sense that Congress is finally coming around, that Washington has come to understand that the problem at the border won't go away. And every night, the running shoes fly in the darkness as would-be immigrants, by the hundreds of thousands, vote with their feet.

Hank Hays and James Ellis find respite from heat and turbulence at the Nogales airport coffee shop.

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AIR FORCE

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The HOTOL Man

Alan Bond designed a revolutionary engine for a British space plane. Now his government won't pay for it—but will they let it go?

by Tom Huntington

Photographs by Michael Freeman

Alan Bond is driving near his home in south-central England, pointing out objects of interest as he speeds around the curves of the narrow country roads. The ridges are dotted with Neolithic and Roman barrows, and on a nearby hill is the Uffington White Horse, a huge Iron Age figure carved into the soft chalk—why, no one knows. Beyond the Horse lie the remains of an ancient fort. It was here, some historians believe, that a British chieftain died in battle, perhaps the basis for the legend of King Arthur.

But Bond is concerned less with Britain's past than with its future: he thinks the United Kingdom is hearing the last call to join the race into space. "We are literally months away from an absolute

Alan Bond, a child of the Space Age, sees Britain stuck in the Stone Age unless government policies change.

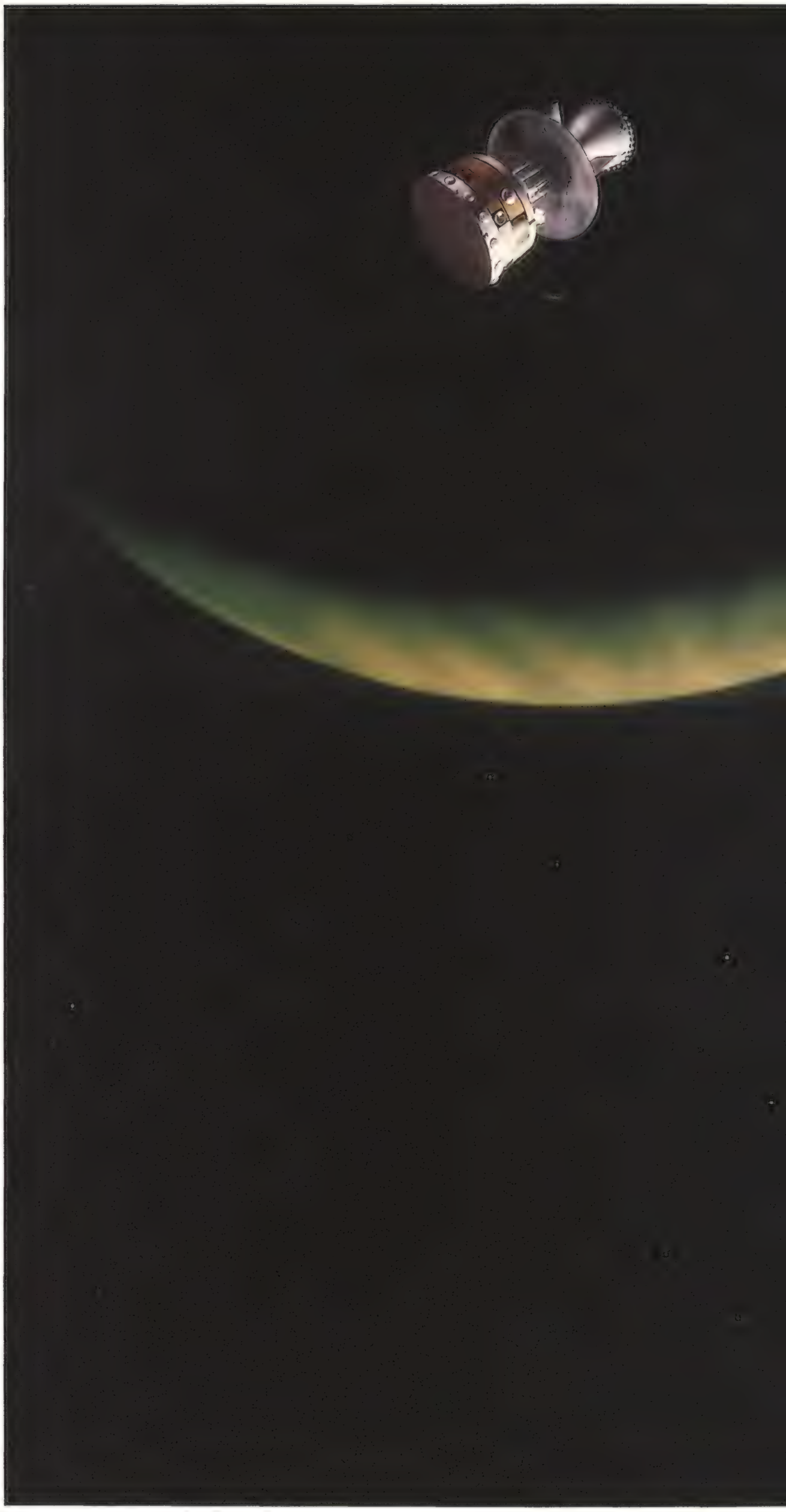
crossroads in Britain's presence in space," he says. "What the present government seems not to want to take on board is that they are the last government that will have a chance to get it right.... A hundred years from now Britain might be completely unknown as an aerospace-faring nation."

Bond is hardly a disinterested commentator. He's the designer of a revolutionary engine for HOTOL, a British horizontal-takeoff-and-landing space plane, and he worries that it may never get off the drawing board, much less the ground.

He lives about two hours from London in Stanford in the Vale, a small village in the county of Oxfordshire. His home, in a development of modern tract houses, is within sight of the village church and graveyard. The house is comfortable and neat. Two small rockets—one atop a cabinet, another beside a couch—decorate his otherwise spartan living room. A framed photograph of a Rolls-Royce rocket engine test firing hangs on one wall; a copy of *Sir George Cayley's Aeronautics 1796–1855* lies on a coffee table. His personal computer waits on the dining room table.

He is a pleasant, somewhat reserved man with serious, light blue eyes behind wire-framed glasses. He speaks slowly and precisely in a deep voice that sounds somewhat underspeed, like a tape recorder with weak batteries. But Bond's low-key manner can be deceptive. A London newspaper once described him as the "Boffin who risks prison to put Britain on top of the world" after he threatened to take HOTOL's classified engine design to a country that would appreciate it. He is a man with a mission his government doesn't share.

Born in 1944 in the small town of Ripley in Derbyshire, Bond admits to acquiring a form of tunnel vision at an early age. "I was castigated all the way through my school days for having what they would regard as an extremely narrow view that things like English and foreign languages, classical history, never meant a great deal to me, whereas the sciences were always very



To Barnard's Star on fusion power was the goal of Daedalus. Bond met future colleagues doing this study.

Superhero Dan Dare's adventures in space proved an inspiration to the young Bond.

fascinating," he says.

The fascination was fueled by England's night skies and a comic strip called *Dan Dare: Pilot of the Future.* "Back in the late '40s up in Derbyshire, street lighting was very sparse," Bond remembers. "We used to get beautiful night skies up there. And you can't live in an area like that . . . and not recognize the sky as something absolutely extraordinary."

Dan Dare entered Bond's life and imagination when a cousin loaned him the *Eagle,* a weekly comic magazine that featured the exploits of the intrepid spaceman and his team of adventurers. "I remember the realization that what Dan Dare was doing was not standing on the ground and looking at the sky," he says. "The thing that dawned on me is that it's not just something to stand and look at from the ground. You can actually *go* there."

But not easily. The trip to Earth orbit requires massive boosters and immense quantities of fuel. The space shuttle can carry about 55,000 pounds of cargo into orbit, but that's a mere 1.2 percent of its weight fully fueled. The shuttle uses rocket engines, which carry their own oxidizer to burn the fuel. A spacecraft with an air-breathing engine would use atmospheric oxygen during its ascent, thus eliminating the weight of the oxidizers. Bond's engine design, the highly classified Rolls-Royce RB545, combines attributes of both an air-breathing engine and a rocket, which is what makes HOTOL so appealing. (HOTOL certainly can't depend on its looks for appeal: it will fly unmanned, and its windowless fuselage gives it the appearance of a blind cave fish.)

After being launched from a jet-propelled sled, HOTOL would use its air-breathing mode to fly to the upper reaches of the atmosphere, then convert to a rocket for a final boost into low Earth orbit. Upon completion of a mission, such as the placement of a satellite, HOTOL would re-enter the atmosphere and return to the airport. There, the craft would be prepared for its next mission, perhaps in as little as 48 hours. HOTOL's payload capability would range from seven to 11 tons, and its proponents say the vehicle could lift that cargo into orbit for one-fifth the cost of an equivalent shuttle mission.

In 1960 Rolls-Royce engineer Arthur Valentine (Val) Cleaver, one of Britain's premier space scientists, read about a 16-year-old's wrangles with the government over permission to launch a model rocket. His interest piqued, Cleaver arranged a meeting with the young Alan Bond. "That was really the first time I'd met anyone who, if you like, was a kindred spirit," Bond says. He joined Rolls-Royce's rocket division shortly thereafter.

Following cutbacks in the British space effort in the late 1960s, Bond took a job with the British Aircraft Corporation. His weapons work there remains classified today, but the need for secrecy is contrary to his nature. "I like to discuss my interests," he says. "But all of a sudden, because of the extremely tight security associated with what I was doing, I found I was very inhibited on how I could talk to people." His marriage suffered, and he and his wife soon broke up.

Career frustrations led Bond back toward space. He headed Project Daedalus, a study for the British Interplanetary Society on the feasibility of sending a fusion-powered spacecraft to Barnard's Star. The project brought together like-minded individuals whose paths would cross in the years ahead. One was Gerry Webb, who became a close friend and the co-founder of Commercial Space Technologies, a consulting group in London. Tony Martin, another Daedalus member, today has an office adjoining Bond's at Culham Laboratory, where Bond works three days a week on fusion technology for the Atomic Energy Authority.

A third colleague, Robert Parkinson, later became one of the originators of HOTOL. He met Bond through a Rolls-Royce project. "We were both fairly junior engineers," he says. "Alan used to come down with a group of ladies who used to do our data analysis, and so we used to work together .... We've met at conferences and things over the years and always tend to sit together over a pint of beer and invent things."

At one of those conferences the

Bond's RB545 engine would breathe air to propel HOTOL to the fringes of space, then shift to liquid oxygen.

French space agency was touting its planned Ariane 5 launcher, which would, among other tasks, boost the French mini-shuttle Hermes into orbit. "[They] were hyping this up as the way to go into the 21st century, using throw-away launchers and things that looked not too dissimilar from the Titan 3 and the Dyna-Soar of the 1960s," Parkinson recalls. "And Alan, sitting next to me, muttered something of the nature, 'There must be a better way of doing it than this.' "

Bond and Parkinson went off in separate directions to work on the problem. Bond concentrated on the powerplant. Through his own company, Reaction Engines, he worked as a consultant to Rolls-Royce and developed the RB545 engine. He patented his design, but Rolls-Royce had the option to purchase the patents if it felt the engine had potential. Parkinson concentrated on the general problems associated with a single-stage-to-orbit vehicle, and he joined the space and communications division of British Aerospace, which became interested in the HOTOL concept.

A two-year proof-of-concept study, funded half by the government, half by British Aerospace and Rolls-Royce, was completed in 1987. "At the end of those two years we said, 'We haven't found anything that makes it impossible,' " says Parkinson. But last July the government announced that it would provide no more money for HOTOL; that was the responsibility of private industry, according to the funding officials.

The decision wasn't unexpected. Space has never been a high-priority area in Britain, which wasn't engaged in the Cold War rivalry that stimulated the extensive space programs of the United States and the Soviet Union. When Britain needed access to space, it piggybacked its projects onto U.S. vehicles. The 1971 launch of the Prospero satellite from Woomera, Australia, was the first all-British satellite launch—and the last.

Although Britain is a member of the 13-nation European Space Agency, it participates with increasing reluctance. On the eve of the 38th Congress of the International Astronautical Federation, held in October 1987 in Brighton, England, Britain announced that it would limit its financial support of ESA

Sandy Burns (top) now supervises the technical aspects of HOTOL's development at British Aerospace. A two-year study proved that the concept can work, says BAe's Robert Parkinson, a Bond friend since the Rolls-Royce days.

projects, a move that essentially killed any chance of ESA's supporting HOTOL. In a statement regarding the cutback, Minister of Trade Kenneth Clarke referred to the European space establishment as a "hugely expensive club" and termed its programs "over-ambitious."

Even among British space scientists, ESA's projects have been received with mixed feelings. For one thing, the space agency has historically been dominated by the French, for whom the British feel a mild distaste. "The French are our traditional enemies now for donkey's years," says Bond. But if the Hundred Years' War hasn't really ended, the hostilities have been tempered by a grudging admiration for France's ability to push ahead with projects—Hermes, Ariane 5—even if the British doubt their ultimate value. "[Hermes] cost a lot of money for an end that wasn't terribly well defined," Parkinson says. "It was probably putting a Frenchman in orbit, which was not particularly attractive to the U.K. government."

Nonetheless, Clarke's statement raised hackles at the Brighton conference. "We had to suffer . . . the insult of a minister with absolutely no comprehension of the field telling an international meeting at Brighton that they were a club of enthusiastic—well, basically 'amateurs' is the bit he missed off the end," Bond says, still angry. "I mean, he handed out what can only be regarded as an insult." Bond responded to Clarke's announcement with one of his own—he threatened to peddle the RB545 to other countries.

The British government was not amused. "Well, certainly my statements caused a great deal of anxiety around government circles," Bond says. And at Rolls-Royce? "There was a substantial personal exchange between Rolls-Royce management and myself, let's say. And I think that in the end we agreed to disagree." In any event, the company effectively defused Bond's threat by taking up its option to purchase the engine patents—for a "pretty considerable sum of money," says Bond.

Bond's position with HOTOL now is largely unofficial. While the project doggedly pursues government funding despite being turned down, he has offered to provide advice and information. "And they're keeping me informed on what they're doing and where things are going, at least to the level that they feel they can."

Both Rolls-Royce and British Aerospace seem to welcome his advice. "He's very quick to point out where it's going wrong," says Brian Lowrie, Rolls-Royce's chief engineer for high-speed propulsion. "We haven't found him wrong yet."

"Certainly we want—we value—his continued involvement in the project," says B.R.A. "Sandy" Burns, the project's technical director. But the technical side of HOTOL is virtually out of Bond's hands. Despite his distance from it, he has been busy working to ensure its future care and feeding. To complete a three-year enabling technology phase, HOTOL needs £120 million, and Bond has been trying to find funding, a quest he thinks may be ready to pay off. He hopes to see HOTOL take wing through the efforts of a multi-national organization of private companies, along the lines of the effort that created the Tornado, a European fighter aircraft, or better yet, a government-subsidized organization like the successful Airbus consortium.

Whatever its source of funds, HOTOL will still have to reach out to Europe. Says Bond, "We recognized a long time ago that maybe only 30 or 40 percent, at the very most 55 percent, of HOTOL could ever be built in Britain anyway, because our industry has now disappeared to the degree that we couldn't do it ourselves."

Not pretty but cheap: advocates claim HOTOL can deliver payloads for one-fifth the cost of shuttle service.

Surrounding most of the Wiltshire village of Avebury is a large Neolithic circle of stones, a structure cloaked in the same mystique that pervades its more familiar cousin, Stonehenge. "I don't believe in magic," Bond says, "but if it did exist it would be here." The Avebury circle is much larger but less elaborate than Stonehenge. Many of the stones have been battered and broken from recurring attempts to destroy the "pagan" structure. The area's green fields, the flock of sheep grazing among the stones, the encircling bank, and the tiny village together create a classic pastoral scene.

Bond wanders among the stones, jacket over his shoulder, and talks about Avebury. He is fascinated by the structure and wonders about the motivations behind the enormous project, speculating that it represents about 30 percent of its builders' gross national product. He has studied the possibility that it was used for astronomical observations, as some believe Stonehenge was, but all the theories he's tested have "fallen flat on their faces."

Perhaps in Bond's fascination with Avebury he imagines its designer, beset by small-minded tribal chieftains who could not envision the worth of such an immense project. "In my youth, of course, we'd just been involved in fighting the war and national prestige was quite high . . . . And we took a pride in our Spitfires and our big ships like the *Queen Elizabeth* and the *Queen Mary*. We took a pride in our railway. These days we don't take pride in anything."

Why, then, would a space scientist want to stay in England? Bond responds that the question is a difficult one. Despite his threat to pack up and take his engine with him, it's clear he doesn't want to. "I've got deep roots in Britain," he says. "It's got a lot of things that appeal to me in terms of climate, such as it is, and culture, heritage, all that sort of thing. That's what I grew up in and that's what I actually like.

"In terms of satisfaction with regard to space work, then eventually I may well have to go anywhere else if I intend to pursue that. The big dilemma is where to go. There are three major options that are clear: America, Japan, and Europe, whatever that might mean . . . . My fundamental interest is in seeing this space transportation infrastructure happen and not necessarily HOTOL just happen—HOTOL is my baby but it's only one baby in a million and the sacrifice of that one if that was necessary might be worthwhile.

"I think it was Napoleon who referred to the British at Waterloo as lions led by a donkey," says Bond. Such a comment—particularly from a Frenchman—stings. Even worse for Alan Bond is the conviction that after all these years the metaphor is still apt. ✈

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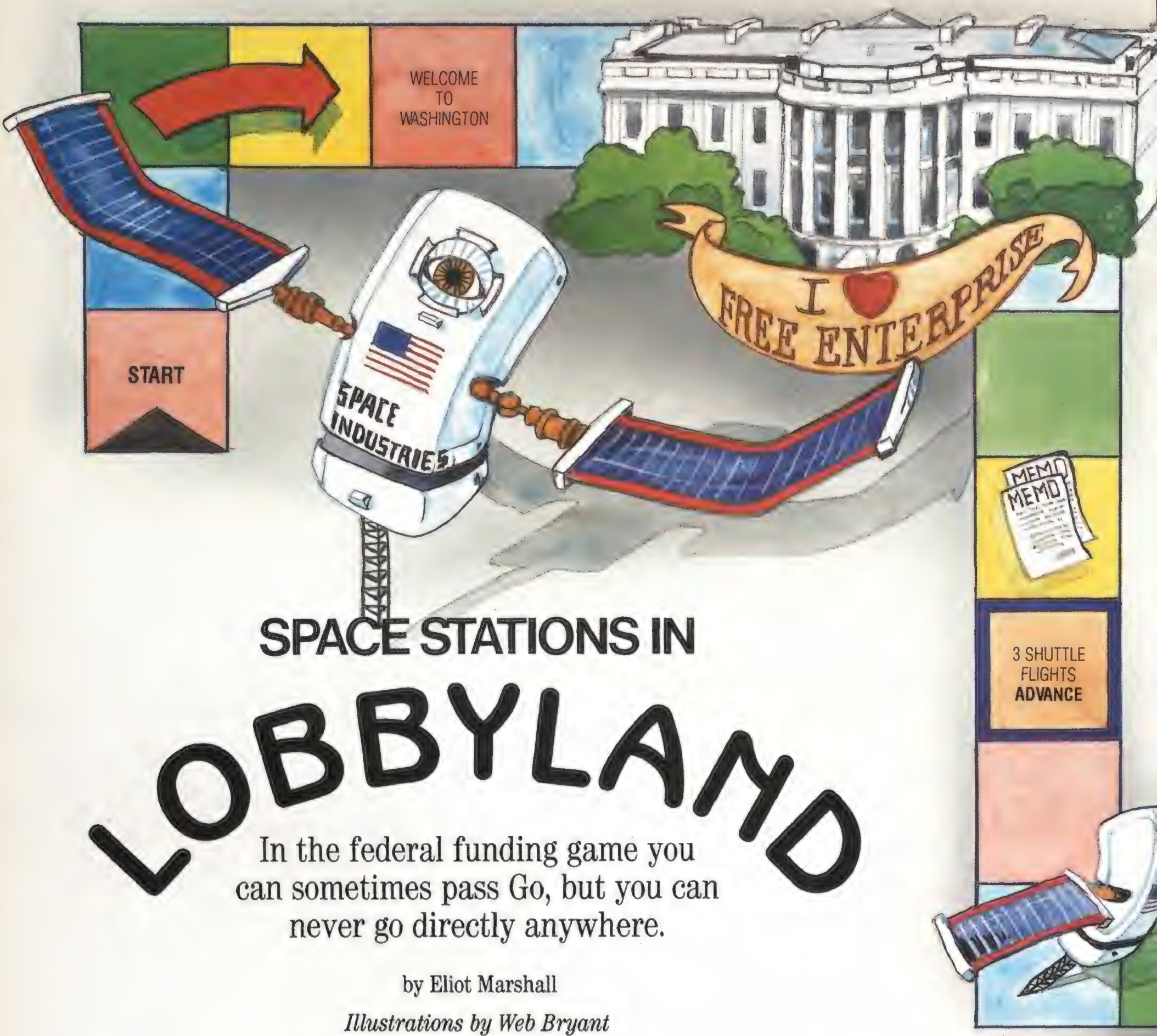


SPACE STATIONS IN LOBBYLAND

In the federal funding game you can sometimes pass Go, but you can never go directly anywhere.

by Eliot Marshall

Illustrations by Web Bryant

A little space station, the Industrial Space Facility, stepped onto the national stage early this year as the brightest new idea for the commercial development of space. It came all the way from Houston to compete in the Washington game of dealing for dollars. But as it made its moves through the maze of federal funding decisions, the ISF triggered a series of wars in the aerospace establishment. Agency was set against agency, Congressional committee against Congressional committee, and company against company.

NASA clashed with the Department of Commerce and the Economic Policy Council, a powerful arm of President Reagan's cabinet chaired by then-treasury secretary James Baker III. To the stubbornly pro-business secretary of commerce, C. William Verity, the ISF became the means by which private industry could get into the space business. To NASA management, the ISF was a dangerously poor space station substitute.

The Congressional appropriations committees were set against the authorization committees. Senator William Proxmire, the self-appointed champion of the taxpayer who invented the Golden Fleece Awards, had consistently resisted spending on NASA's big space station. And when he and Edward Boland, the Democratic chairman of the House

appropriations subcommittee, directed NASA to write the ISF into the budget, the authorizations committees, which guide long-term policy, evinced a parent's nervous concern for the space program and jumped into the fight.

In NASA, studies that had been done by space science and engineering offices contradicted decisions made by NASA heads James Fletcher and Dale Myers. And there were the predictable battles between political parties. Democrats Ernest Hollings, the irascible chairman of the Senate commerce committee, and Donald Riegle Jr., chairman of the commerce Subcommittee on Science, Technology, and Space, persuaded Boland to join them against the Republicans in the White House.

In the end, the little station got caught in the crossfire, perhaps a portent of battles to come in the 1990s, when more bright ideas will be chasing even fewer federal dollars.

A look at the ISF's journey this year—through a Washington maze that took it from nowhere to celebrity and back again—is a disturbing revelation of the colliding interests and power plays that make national policy.

The ISF is the brainchild of Maxim Faget, the spacecraft designer who made fundamental contributions to the Mercury, Gemini, Apollo, and shuttle vehicles (see "Max and the Mini-Space Station," p. 58). Faget is president of Space Industries, Inc., a Houston company formed in 1982 to build his idea, the small orbiting laboratory, and lease it to private companies and the federal government for long-range, low-gravity experiments and materials processing.

Faget wanted to give the shuttle a place to go, and he wanted it to go there quickly. "When I retired from NASA in 1981," Faget told the House space science and applications subcommittee last March 23, "I could see this major gap developing" between the shuttle, which was finally operating, and the shuttle's destination, the space station, which was nowhere in sight.

The space station still requires an extended period of design, which is just beginning, and may be operating in 1997—if more than $16 billion can be secured in a series of federal budgets over the next eight years, and if the shuttle completes the 20 flights needed for assembly by that time. Space Industries proposed to put the ISF in orbit no later than 1993 for less than $1 billion, offering more room, more time in orbit, and more power than any U.S. research facility since Skylab.

The ISF would be "man-tended," not manned. Astronauts could visit periodically—three times a year, say—to set up and take down experiments. The rest of the time the capsule would care for itself, relying on computers and robots powered by solar electricity. The experiments would not be limited to the length of a shuttle flight; they could last for months. And the equipment could be left in orbit, instead of taking up space in the shuttle. Space Industries presented the ISF as the logical interim step to the space station.

In 1985 NASA saw it that way, too. James Beggs, then NASA's administrator, signed an agreement with Space Industries promising three rides on the shuttle on credit. Once Space Industries was making money, the company agreed, it would pay NASA 12 percent of its gross revenues until the transportation costs were paid off. Back then, the cost of a shuttle flight did not seem unreachable—around $70 to $80 million. The current estimate is somewhere between $110 million and $300 million.

But in 1985 shuttle trips were becoming routine. NASA wanted to encourage industries other than aerospace to hop on board. When Beggs announced the contract, he spoke of building "an industrial park in space." The Industrial Space Facility would

"give a head start to companies investigating opportunities in space-based materials processing and other activities because it will provide them with a place in orbit to work even before the space station is in orbit . . . ."

Still, obstacles remained. As the Space Industries partners learned more about the market in microgravity research, they found that there was more basic experimentation ahead than they had earlier believed. Then *Challenger* exploded in January 1986, and the situation became more desperate. "After *Challenger,*" says Joseph Allen, an ex-astronaut and former NASA liaison on Capitol Hill, who is now an executive at Space Industries, "the choice was to shelve the project or interest the federal government in becoming the 'anchor tenant.' " Although the need was even greater for a microgravity lab in addition to the shuttle, private investors with no guarantees of a launch could not undertake the financial risk. Allen and a Space Industries founder, James Calaway, consulted Congressional aides and members of an interagency working group on commercial space about federal loan guarantees. The advice they got was to seek instead a NASA commitment to lease 70 percent of the ISF. The promise of rent would secure loans to pay for the project's development. To its request for shuttle tickets Space Industries added a request for money, and in Washington, money changes everything.

In the fall of 1987, while Allen and Calaway were selling the ISF on Capitol Hill as an excellent test bed for equipment to be used later on the big space station, Congressional appropriations committees were bloodying NASA's 1988 space station budget. Senator Proxmire, who referred to the station as "the space palace," was infuriated by NASA's $767 million request. He liked the ISF. Its total cost—estimated at that time as $400 million in rent—was less than a single year's costs for space station development. Besides, the ISF offered an earlier berth for U.S. research projects. And if by chance this little project made the big space station unnecessary, so much the better—the public would save that much money.

On the House side, Edward Boland and Bill Green both advocated a strong space program, but appropriations committees are faced with hard, short-term funding decisions that must take into account the needs of several agencies. They can't afford to be as sympathetic to NASA's institutional goals as authorizing committees can be. Nonetheless, Boland and Green were anxious to get microgravity experiments running within five years in order to compete with Soviet and European projects.

These interests came together at Christmas in 1987. Suddenly a gift for the Industrial Space Facility appeared in the catch-all federal funding bill, the continuing resolution (PL 100-202). The appropriations subcommittees asked that a first installment of $25 million be set aside for a future lease and directed NASA to "conclude a satisfactory funding arrangement that will lead to a workable leased ISF vehicle in the 1991/1992 time frame."

They also cut NASA's space station budget almost in half. The $25 million earmarked for the ISF, a project for which NASA had not sought support, was to come from the remaining amount.

NASA management was ready. Despite a series of internal reports that endorsed the ISF—astronaut Bonnie Dunbar's study on microgravity research, NASA's 1987 task force on scientific uses of the shuttle, and a report from six NASA Centers for the Commercial Development of Space—NASA headquarters had ordered another report on the need for microgravity research. This study concluded that the ISF would be a burden on the budget, increase the risk to shuttle operations, and "meet few scientific requirements of the agency." The NASA chiefs were further galled that not one of the other agencies that liked the ISF had offered to pay for it in the 1987 year-end survey by the Office of Management and Budget. The agency chiefs geared up for battle.

NASA Administrator James Fletcher, who had returned to head the agency in 1986, op-

posed the House action by writing a series of letters to people in the space policy establishment. On January 6, Fletcher wrote to the heads of the appropriations committees in the House and Senate—Green, Boland, and Proxmire—saying that NASA "did not [in 1985, when Beggs committed shuttle flights to ISF] and does not now have identified needs that would justify a major commitment to use the ISF . . . ." The Congressional trio fired back a sharp letter, threatening to withhold $90 million in space station funds "until these issues are settled." They added: "Often it appears that there is an element within NASA that is only interested in building a permanently manned space station." In between this exchange of letters, a *New York Times* editorial called the ISF "a carefully designed, cost-effective way of exploiting specific goals in space."

In the administration, NASA was alone in its perception of the danger to the space program. At the same time that Proxmire and Boland were savaging the space station on the Hill, Secretary of Commerce C. William Verity and the other members of the Economic Policy Council were meeting across town, searching for ways to encourage private investment in space. The council's crusade was best expressed by Gregg Fawkes, then director of the commerce department's office of commercial space programs. Fawkes, who left government service last June, was eager to obtain a tangible victory for his cause: chipping away at what he calls the rigid "monopoly control" that NASA exercises. Entrepreneurs have "cheaper, more creative" ways to do things, says Fawkes, who believes NASA is not receptive to their ideas. He blasts the "old school traditionalists" who run the agency, people who think that "NASA is the only one who knows how to do space," who "don't understand what 'commercial' means in space and wouldn't like it if they did."

The ISF made sense to the Economic Policy Council, especially to Verity and Secretary of Transportation James Burnley IV. They read back to NASA leaders conclusions from their own reports, which favored the ISF. On January 7 the council voted to overrule Fletcher's objections.

On February 11, Fletcher joined Verity and Burnley on a dais at the White House and unveiled a new space policy for the Reagan administration. Its theme was the commencement of a new age of private investment, a policy intended to assure U.S. companies that "the government will get out of the way." The centerpiece of this effort was the concept of a small, orbiting, man-tended space facility that would encourage private corporations to invest in space. It was the ISF concept—only it wasn't called the ISF anymore.

Muscled into accepting the idea of a man-tended facility, NASA had fallen back on the position that the project should be subjected to open competition, not simply taken as a sole source procurement from Space Industries. Burnley agreed and insisted that a request for proposals be advertised. NASA promised to get cracking, run a competition, and sign a lease within 150 days. The concept was given a new generic name, the Commercially Developed Space Facility (CDSF), and Space Industries was invited to compete for a program it had proposed, partially financed, and lobbied through Congress.

It appeared that the administration's zeal for private enterprise had overcome NASA's protective ardor for the space station, but only briefly. By the beginning of the summer, the CDSF was nowhere on the priorities list.

"It got bushwhacked by the worst kind of insider politics," says a nonpartisan technical advisor on Capitol Hill. He is a direct witness; his friends did some of the whacking.

The space authorizing committees now insisted on their right to review the idea. They

flattened it. Ernest Hollings and Donald Riegle Jr., chairmen of the Senate Commerce Committee and its subcommittee on space, warned the White House in March that new legislation would be needed and that they had authority to clear it. They argued that the CDSF was a policy matter to be authorized before the appropriations committees could act.

In the House, Florida Congressman William Nelson convened a hearing before his space science and applications subcommittee on March 23, saying the earlier money for ISF had appeared "from out of the blue" and now he had "a host of questions" that "need some answers."

Max and the Mini-Space Station

Spacecraft designer Max Faget found himself in a familiar position this year when he brought his Industrial Space Facility to Washington. Almost 10 years ago, when he was chief engineer at the Johnson Space Center in Texas, he had suggested that launching a small, self-supporting module be the first step to NASA's next major project: the first permanent, manned space station.

The large, complex structure countered the design philosophy that had guided Faget when he worked on the Mercury space capsule. "I always try to find the simplest solution to any issue," he says. "Before I get started, I work very hard to be sure the basic approach is as simple as possible."

Faget had spoken out against complexity before. In the late 1950s, when conventional wisdom held that a manned spacecraft should take the form of a highly streamlined airplane, Faget, then an engineer 10 years out of Louisiana State University, backed scientist Harvey Allen, who argued that the proper shape would be a blunt-nosed cone. "The problem was to find the shape that would have the least amount of heat going into the vehicle," Faget recalls. "Other people could understand the problem in those terms, they just didn't like the approach. They wanted to fly an airplane. A blunt body with a man in it? That was abhorrent." Faget prevailed. The Mercury capsule was a blunt-nosed cone, as were the two-man Gemini spacecraft and the later, larger Apollos.

In the early '70s he opposed, again successfully, a space shuttle designed with complex "hot structures," featuring exotic temperature-resistant metals. Instead, he proposed that the craft be an aluminum airplane, with structural forms that any aircraft design shop would understand. For protection against the fierce heat of re-entry, Faget's choice was an outer layer of heat-resistant tiles.

Finally, in 1981 he contended that even the first component of the space station in orbit should be able to support useful work, rather than require additional elements to make it operational. There were many competing concepts at the time, and Faget decided against joining the struggle.

"I would say I showed great foresight in not getting involved," Faget says today. "People had already made several attempts to get a space station started. It would go so far, then languish for lack of funds. I was convinced there'd eventually be a space station, but I was also convinced that by the time it made its debut in space, I would not be part of the program. And I didn't want to get involved in something I couldn't finish."

Faget was 60 years old. He had been in the government at the forefront of the U.S. space program for 38 years, his work on the shuttle was completed, and, as he puts it today, "there were no major programs on the horizon, and I liked big programs. It looked like the station program was beginning to stall out."

He left NASA and joined Eagle Engineering, a Houston firm that does engineering studies for aerospace companies. Two Houston architects, Larry Bell and Guillermo Trotti, along with James Calaway, a recent Oxford graduate whose family had long been in the oil business, approached Faget there. They wanted to put some sort of outpost in orbit, possibly a commercially operated space station. They had no preconceived notion of which way to go, however, and hoped to benefit from Faget's experience.

Faget easily convinced the businessmen of the point his former agency hadn't bought: that a space station would be far too ambitious. "The total cost would be prohibitive," he says. "The problem with a big space station is that you have to put up a great many pieces and assemble them in orbit before you have anything that's revenue-producing. That led me to say, Why don't we try to put up one component at the very beginning that would indeed be productive? After we got that far, the rest came rather easily."

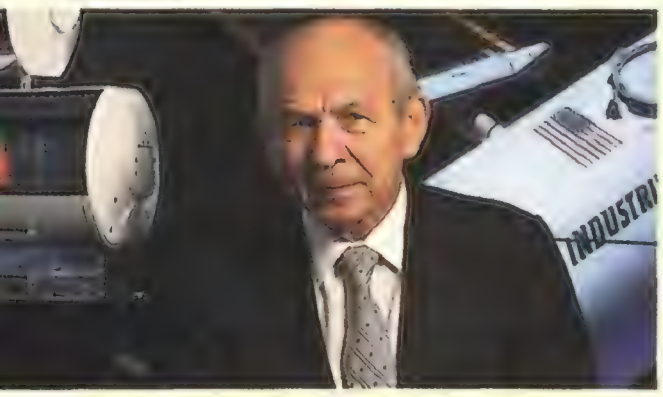
"The rest" was the design of an orbiting laboratory, and Faget proceeded as he had in the past. His former inventions were not the products of quick flashes of insight but of days, sometimes weeks, of steady concentration. "He was always thinking," his former secretary, Betsy Magin, recalls. "You could pass him in the hallway and he might not see you. Some people would think he was being aloof or unfriendly. But he was very friendly; he just would be deep in thought, because his mind was working constantly."

Faget recognizes the description. "I go into the bathroom to brush my teeth; it takes a half-hour. I'm standing there thinking the whole time. It drives my wife crazy."

To help plan a mini-space station Faget enlisted an old friend and former NASA engineer, Caldwell C. Johnson. As Johnson says, "I had retired but he said, 'You want to work on this?' Well, I was tired of fishin' and hittin' a golf ball. Max said, 'We ought to have a commercially developed space station; it's something

NASA deputy administrator Dale Myers was asked to explain the agency's sudden change of heart between Fletcher's January barrage of letters and the February 11 announcement of the commercial space initiative. Myers' response was awkward. A new study of the proposal carried out between January and February led NASA to a fresh "understanding" of its potential, Myers said. He mentioned other considerations, including the fact that the Economic Policy Council at the White House was looking at ways to boost private investment in space and had focused on ISF as "one of the best ways to do it." He said that just hours before the space policy was an-

DAVID NANCE



Despite ISF wars in Washington, Max Faget is "still dedicated to the cause."

the world needs.' Now, I don't go around having great thoughts and great insights as to what we need. Max does. I'm better at taking the overall thought and turning it into a practical design."

It took about a month to develop a good working concept. "It was like we did it in the 1950s," Johnson says. "We said, 'Let's don't invent anything new; let's just take things we've got and artfully put them together.' "

They christened their concept the Industrial Space Facility. Faget left Eagle Engineering and set up a company, Space Industries, Inc., in a small office building several blocks away from the Johnson Space Center. Eagle Engineering helped with some initial funding; other support came from what James Calaway describes as "individuals with high net worth in the Houston area." With this start, Faget, Johnson, and Calaway, with the help of Macomb Dunwoody from Inverness Securities of Houston, began soliciting venture capital. At the same time, they started looking for tenants for their orbiting lab.

The prime candidate was McDonnell Douglas. James Rose of that company, working with Johnson & Johnson, was developing a system for making pure pharmaceuticals in space. He was testing it aboard the shuttle, hoping to build a larger version—"a factory"—that would produce erythropoietin, which stimulates bone marrow to produce blood cells. Rose would then seek Food and Drug Administration approval to produce the substance commercially in space.

Johnson and Faget refined the ISF for the McDonnell Douglas factory. "That looked like the best customer. We designed it to take two of them," Johnson says.

"We talked to a number of companies," says former astronaut Joe Allen, who joined the company as executive vice president. "They would be interested if there was a steady level of research in microgravity, on 10 to 12 shuttle flights per year, that would lead to manufacturable products."

Boeing, for one, had a concept for growing semiconductor crystals from vapor, a faster method than the established one. The company eventually formed a partnership with Space Industries. General Motors was collaborating with the tractor firm John Deere. The two companies were interested in producing new alloys in microgravity. In gravity the alloys separate into their constituent metals because of mutual insolubility, but in microgravity they remain well mixed. Producing these alloys would test the feasibility of manufacturing high-strength magnets. The 3M Company was interested in basic research on the mixing of organic solutions; experiments done in space would provide baseline data to guide work on the ground.

Marketing studies showed, however, that a great deal of basic research remained before work in microgravity would turn a profit. The *Challenger* explosion compounded the problem, and Space Industries is now waiting to see if the federal government will step in. The company is also looking for overseas customers.

Faget regrets having to go outside the country, but he believes that the U.S. government is moving too slowly to encourage a private space industry. "The government could do more research and development while encouraging private industry to get into operations," says Faget. "There is no space-produced product right now that would produce revenue for private industry," he admits. "We thought we had one, in pharmaceuticals, with McDonnell Douglas' factory. There was also some enthusiasm for electronic crystals, though that's moved more from pilot plant to research. So research has to be done, and it's too expensive for companies to pursue. The European and Japanese governments are willing to support their industries in microgravity research. Why doesn't our government do the same thing?"

Although the fortunes of his company have not been smooth, Faget does not regret leaving NASA. According to his friends, Faget likes to be in charge. Betsy Magin recalls an occasion when several people from the manned-spaceflight group were taking dance lessons. "We made quite a pair on the dance floor," she says. "He's about five foot seven and I'm more like five foot fourteen. We learned to jitterbug. He'd take me out on the floor and he'd twirl me all over the place. And he was in control."

—T.A. Heppenheimer

nounced, NASA leaders received a new briefing that changed their perspective.

His answer raised more questions about who makes space policy and which policy is in place to guide priorities in a time of lean space budgets. Another Florida Congressman, Buddy MacKay, summarized the problem in the questions he posed to Myers during the hearing. He listed some big projects already under way: buying expendable rockets, improving the shuttle, building the space station. "You're going to have a continuing need for 15 percent to 20 percent increases at a time when the overall U.S. budget is being cut," MacKay said. "Don't you understand that we're going to end up in a situation where there's no way in the world this can happen?"

Influential private concerns weighed in against the CDSF, including Spacehab, Inc., an outfit headed by former NASA administrator James Beggs. Spacehab is a pressurized, private research module to be carried on the shuttle. It would have trouble marketing its services if the more spacious ISF capsule were starting up operations at the same time. Beggs wrote Nelson that the "conditions now being proposed for the CDSF are significantly different" from those he agreed to in 1985 as NASA's chief. They "threaten the viability of Spacehab." Beggs claimed his company could provide some of the same services "at greatly reduced total costs."

Meanwhile, the House backed away from its previous commitment. Under pressure from Nelson's committee, appropriations subcommittee chairman Edward Boland announced that he would rescind the $25 million pledge made to the ISF in 1987.

And still the administration held fast to the little laboratory. Several congressmen felt that the White House lobbied more effectively all spring for the commercial space facility than for the big space station. In the final debate on NASA's appropriation in June, it looked as though the space station might die of neglect. Longtime NASA supporter Senator Jake Garn made a desperate plea to the White House for help in saving the station. Garn received a limp response from the president that shocked some senators. The "Dear Jake" letter, dated June 16 and signed by Ronald Reagan, used bland terms and gave equal weight to the CDSF and the space station. Both of them, it said, along with the shuttle, "are essential to maintain national security, economic growth, and international competitiveness." A top congressional aide on Riegle's staff, who was a critical go-between in the sometimes frantic dickering among cabinet officials and Senators, is amazed by the tenacity of the administration's support for the project, despite Congressional resistance and the risk of undercutting the administration's supposed number one priority, the big NASA station. "Nothing was happening on the space station," he says, despite congressional threats to kill it, "but the ISF took 60 percent to 70 percent of my time for 3 months—and the same was true [for the staff] at the top levels of NASA."

Led by commerce secretary Verity, the administration tried to ram the leasing agreement for the CDSF through NASA despite the opposition. In the spring Verity called an emergency meeting of the Economic Policy

Council at the White House to plan a strategy for going ahead anyway. The proceedings of the meeting are confidential, their secrecy protected by executive privilege.

Negotiations continued for weeks, with phone calls, staff meetings, and summit conferences among Congressmen and cabinet members. On April 28 the heads of the Senate Commerce Committee and the House Science Committee flatly ordered NASA not to proceed with the CDSF competition.

Finally, the House and Senate passed legislation that brought the game to a halt. The new NASA authorization bills defer action on the little space station until March 1989, directing NASA to pay for an independent study by the National Academy of Sciences on the need for a research capsule.

Like an ink blot, the ISF war is interpreted differently by different people. John Pike, a policy analyst and gadfly at the independent Federation of American Scientists, was shocked to see the proposal get as far as it did and was glad to see it stopped. Pike sees the

ISF as a "raid on the Treasury" by investors who failed to get private tenants and turned to Uncle Sam for rescue. It might make sense for the government to rent room for researchers, Pike says, but not without looking for cheaper lodgings first. He says no credible search for alternatives was made.

Jack Anderson, the muckraking newspaper columnist, viewed the ISF's meanderings as a "classic Washington tale of influence and power." Last April 27 he reported that Space Industries had hired the law partner of treasury secretary James Baker as its attorney. The company also retained Richard Darman, former deputy secretary under Baker, for financial advice. Both removed themselves from the government negotiations on the ISF. But the treasury department did lobby for the ISF, and the Economic Policy Council, which Baker headed, made it the center of the president's commercial space initiative.

Courtney Stadd, who headed the transportation department's space office until last summer, confirms that the White House was nervous about these connections. He also says

that even the Office of Management and Budget would have gone for a direct purchase from Space Industries. "But when the *New York Times* backed the ISF, that was the killer," Stadd says. Alarmed contractors for the big space station moved in with a crushing counter-lobby.

A technical advisor on Capitol Hill says, "It was sad to see it collapse. It posed interesting questions. It asked: 'Is there a way to do things fast anymore? Is there any way to *do something* in the space program anymore?' "

Meanwhile, Space Industries' Calaway has packed his belongings and sold his Washington house. He has moved back to Houston, although he says, "We're not leaving town." Having given the United States first crack at leasing the ISF, Calaway says, he can offer it in good conscience to the Japanese, Germans, and other foreigners who are keenly interested in microgravity research.

Calaway may be right in arguing that the big boys of the "aerospace club" rejected the ISF because it was a brash newcomer that threatened the status quo. But this opinion omits some of the special faults in the strategy that Space Industries used to play the Washington money game.

Brashness is no small consideration in the capital city, where rank and protocol are observed. It was a mistake to go for appropriations when the authorizing committees had not passed enabling legislation. Gregg Fawkes claims that the Democrat-led authorizing committees had given tacit support and reversed themselves when it appeared that Reagan was going to take credit for backing the ISF.

It was also a mistake to "go to the White House" with this crusade, as one Congressional aide put it. Calaway insists that his company was invited there and did not try to pull strings. But a company that employs NASA's former Congressional liaison cannot plead naivete in politics. Space Industries should at least have seen the risk in serving as the centerpiece of a new presidential initiative in a presidential election year. Upsetting the applecart is risky; becoming identified with a lame-duck administration in the process is double jeopardy. It is not exactly unusual that Democrats in Congress refused to cooperate with Republicans in the White House.

The ISF will still be in the limbo known as "the Congressionally mandated study" when a new administration comes to Washington with new rules for the federal funding game. Americans who want a strong space program can only hope that the people with the best ideas are the ones who learn how to play.

Masters of Soaring

The world's most skillful players descend on central Florida for the flyoffs.

by Doug Stewart

Photographs by Randy G. Taylor/Compix

The man with the beer belly stands in the grass next to the airstrip, feet planted wide apart, squinting at the sky. On this fine afternoon in early May, a gray wisp appears to be drifting aimlessly below a small cumulus cloud. "Look at him," he says. "He's just flying around in circles up there. He must have given up."

Far from it. The pilot of the sailplane spiraling silently a mile above us is climbing faster than an express elevator in a column of warm air—a thermal—he's found rising from the sun-baked asphalt runway in Winter Haven, Florida. In a few minutes the sleek engineless craft will nose down and hurtle across a 5,000-foot-high invisible starting gate at nearly 140 mph.

The pilot is hoping for a good start in one of the world's elite sporting events: the third annual Hitachi Masters of Soaring, a by-invitation-only competition.

Seven of the 17 pilots competing here are past or present world champions in the three classes of sailplane competitions. The others boast an average of three national championships each. They have not come to Winter Haven for the money—the $20,000 purse, when divided among eight winners, will barely make a dent in the costs of competing—and the tournament has no bearing on the pilots' official standings with the Fédération Aéronautique Internationale, which has the final say on all record flights. For most of the pilots, the real lure of the contest is the camaraderie of a week with one's peers, soaring masters all. It's more a contest for bragging rights among a small group of familiar faces than a winner-take-all championship. Hitachi, the Japanese

Between races, Ray Gimmey unwinds over central Florida.

Sailplane purists spurn powered flight but are not above hitching a ride with a Cessna when they need a lift (inset).

World champion Brian Spreckley begins a day at the races by unloading and assembling his racer.

Eric Mozer keeps a bag of tricks under cover to psych out his opponents.

electronics giant, sponsors the competition because, according to president Tsumeo Tanaka, "the technology allows the athlete to be at one with himself," which Tanaka says reflects Hitachi's philosophy.

To many people, a sailplane is a fragile vehicle that a towplane takes up and a pilot simply glides back down in. In fact, once aloft, an accomplished pilot can climb, glide, and climb again all day, as long as the sun stokes the thermals or the wind blows along the ridges. Far from fragile, competition sailplanes can withstand about 10 Gs.

Virtually all top-of-the-line racers are built in West Germany. Soaring and sailplane technology burgeoned there after the Treaty of Versailles ended World War I and all motorized flight by German citizens. At $45,000, today's Schleichers, Schempp-Hirths, and Grobs cost more than a Porsche 944. They are built of fiberglass, Kevlar, and carbon-fiber epoxy, and their low drag and long, slender wings enable glide ratios—distance covered compared to altitude lost—of 45 to 1 or better. Starting from a mile up, a Schempp-Hirth Nimbus, for example, can glide 60 miles before landing.

"Soaring is a series of climbs and glides," says Doug Jacobs. He is the 1985 world champion in the 15-meter class—sailplanes that have wingspans under 49 feet and use wing flaps—and won the first Masters of Soaring meet in Minden, Nevada, in 1986. "The problem is when you're climbing, you're not making distance—you're stopped. When you're gliding, you're making lots of distance, but you're sinking." The key, he says, is to strike the proper balance between the two. A winning pilot stops to climb only in the strongest thermals for maximum lift in minimum time. "Picking which is the best thermal, though, is a problem," Jacobs says, "because there are no signs up there."

Jacobs was until recently an investment banker on Wall Street, with 200 people reporting to him. Part of the reason he quit was to spend more time soaring. This morning, waiting in his van for the daily pilots' meeting, he is smoking a cigar and reading *The Wall Street Journal* with his feet on the dashboard.

After the first day's race Jacobs had been tied with Ray Gimmey for first place. Then he got greedy. The races are typically 200-mile round trips with the turnpoints for the three or four legs marked by rural airports or highway cloverleafs. "We were coming around the last turnpoint and I was behind," he says. "I was frustrated. The damn problem with this sport is you have to push it right up to the edge—and then stop. It's such a long drop off the back if you push it too far."

Jacobs pushed it too far. From the turnpoint he thought he spotted what sailplane pilots call a cloud street. Zigzagging down these double rows of clouds, like crossing a stream by stepping on stones, is riskier but quicker than thermalling. The pilot picks up a little lift here, a little there, and hopes the lifts keep coming. In Jacobs' case they didn't. He and his sailplane ended up in a pasture—"shot down," in sailplane jargon—and his score dropped 570 points below his previous day's, a fatal setback.

Two days later, with four days of competition complete, most scores are tightly bunched. Out of a possible daily catch of 1,000 points, 11 of the 17 pilots are averaging better than 900 points a day. Nudging out Ray Gimmey for first, despite a 12th-place finish the previous day, is Gabriel Chenevoy, a taciturn 38-year-old gliding instructor and the reigning French national champion.

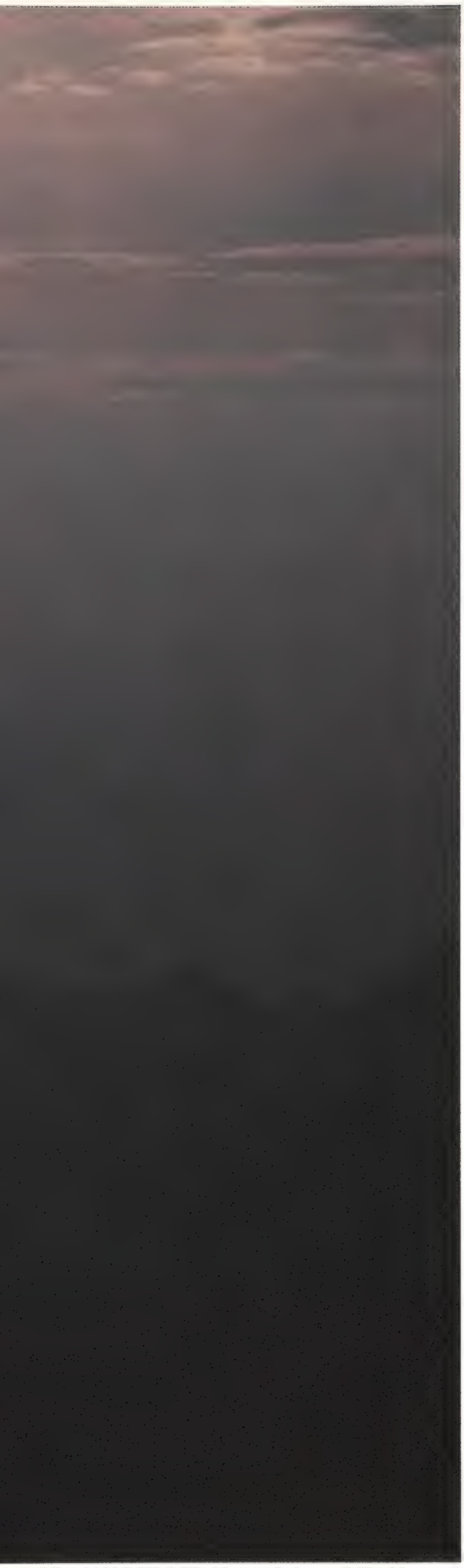
Many of the pilots have been racing and socializing with one another for years, but Chenevoy is a relative newcomer to world-class competition. "Yes, it is more tiring to be first," he admits before the fifth race as he removes the protective cotton covers from his Schleicher ASW-20 sailplane. The fatigue, he says, is more mental than physical. "It is a brain sport. You need to make decisions in seconds, even when you fly quietly."

Dick Johnson, an 11-time U.S. champ, is clinging to 10th place by three points. A trim 65-year-old from Dallas, Johnson flew the wartime Pacific as copilot on Pan American's majestic flying boats. He had switched from model airplanes to gliders at age 15, starting with an open-cockpit homebuilt towed by the family's Model A. "There were no two-seater training gliders in those days, so you had to teach yourself how to solo," he says as he siphons 50 gallons of water into bags in the wings of his Schempp-Hirth Ventus A. The 400 pounds of ballast, which nearly doubles the weight of the aircraft, boosts glide speed but exacts a penalty in a sluggish climb rate. The ballast can be jettisoned to improve climb performance, but pilots usually keep some in reserve until a safe landing is certain.

In fifth place is Eric Mozer, a machinery entrepreneur from Charlotte, North Carolina. Although he is only 33, he is probably the most self-assured member of a very self-assured group. He cuts a glamorous figure with his Hollywood tan, heavy-lidded eyes, and easy smile. All the pilots favor aviator

Chenevoy's team does a ballasting act, transferring 50 gallons of water from an inner tube to the sailplane's wings.

CHRISTOPHER WOODS PRODUCTIONS



Competitors often must share thermals in a sport some call three-dimensional chess.

sunglasses, but Mozer's are mirrored.

"Competition soaring is the world's greatest chess game," he says as he wipes condensation off the wings of his Schempp-Hirth. "You have to think in three dimensions, not two, though. And you have to think fast." Like a chess player, Mozer is not above taking the psychological advantage. "Any time you can cast a little doubt in someone's mind, it helps you," he says. A common practice in regional and even national competitions, he says, is a tactic called leeching: the second-string fliers tag along as a top-seeded pilot does the work of seeking out the thermals. On the final glide home they break away, hoping for a good finish.

"In soaring you can make as many starts as you want," Mozer says. Pilots have an hour and a half to start a race and within that time can make unlimited restarts, as long as they complete the course within a specified period. "If you can lure some people out on course ahead of you, then sneak back and get a new start, they'll mark the thermals for you later." Thermals aren't marked with red letters, but a gaggle of circling sailplanes—"Mozer's Minnows" as they're sometimes called—is a pretty fair indicator. Mozer has also been known to drop hints of approaching thunderstorms to scare off competitors, then make an early, leech-free start. In this tournament, says Mozer, his opponents are "psych-proof." Nevertheless, all week the pilots have been making phony starts, some doubling back for a second or third start after nearly an hour of flying.

Doug Jacobs, who's seen his score rise and fall dramatically, wins the fourth day's race, a 187-mile jaunt to Sebring, Wauchula, Clermont, and back to Winter Haven. At the pilots' meeting the next morning, Hitachi's Harry McGrath presents him with a hundred-dollar bill to be spent on a lavish dinner for the ground crew and asks him to describe how he pulled off a win. Jacobs obliges with a blow-by-blow, telling how he had come in low at one turnpoint, then "ran for some wispies with good lift" and was later "oomphing along to that cloud north of Wauchula." They all seem to know precisely which cloud—sailplane pilots know their clouds as well as they know their turnpoints.

Two hours later the four towplanes have finished dragging all 17 sailplanes to 2,000 feet, where they are released to continue climbing on their own. Here and there they start thermalling, seeking enough altitude to swoop down through the starting gate at top speed. From the ground they are barely visible

slivers as they circle like vultures in the cloudless sky. Without cumulus clouds—"cues" in soaring lingo—to mark their tops, thermals will be hard to find, requiring as much luck as skill. Often the only way pilots find "blue" thermals is to feel the jolt in the seat of their pants. Still, cues or no cues, the thermals are out there, carrying currents of warm air up from the shopping malls, parking lots, and subdivisions across central Florida.

Today's race is free-form, which discourages leeching. Each pilot picks his own turnpoints, hoping to cover as much ground as possible within the four-hour limit.

The trick is to climb only when absolutely necessary; excess height and steep dives at the end of a race waste energy. A resourceful pilot crosses the finish line low and fast. From far below a sailplane resembles a small and graceful bird, but when it streaks in over the treetops and dumps its ballast in an explosion of spray it looks more like a jet fighter on a bombing run.

Sailplanes become water bombers as they jettison ballast at the finish line.

At 4:30 Jacobs' Rolladen-Schneider LS-6b barrels in with a *whoosh* a few dozen feet overhead. Behind him British pilot Brian Spreckley shoots past at the same altitude, trailing a plume of spray. Seconds later Swedish pilot Goran Ax barrels in 10 feet off the runway. The crowd whoops. The tournament's official spotter frantically swivels a huge pair of antique German military binoculars on a tripod. Sailplanes hurtle in from all directions in a tree-skimming ballet. After crossing the finish line at top speed, each craft pulls up and circles to bleed off speed and set up a sedate landing approach, then alights delicately at the far end of the runway.

Bruno Gantenbrink is practically strutting as he pulls his Schempp-Hirth into a hangar. The shaggy-haired shirtless West German national champion rushes up to his wife and hugs her. "Maybe I didn't do too bad. Maybe I did pretty well," he grins, trying to contain his exuberance. "I was only third as of last night but I was only 48 points behind the leader." Like Mozer, Gantenbrink makes no pretense of an "aw shucks" attitude. Both have their sights set on first place. Gantenbrink and French pilot Marc Schroeder speak in German while they spread out their charts and logs on a table in a corner of the hangar, murmuring *"Supergut!"* as they work out their mileages.

Relatively new to international competition, French national champion Gabriel Chenevoy proved to be the *Master of Soaring.*

The results later show that Gantenbrink has indeed carried the day, covering 213 miles of flat terrain on a cloudless day at just under a mile a minute. In the overall standings, he is second. But Chenevoy, the leader, came in fourth today, and Gantenbrink has halved the newcomer's lead. Brian Spreckley is in third place, just ahead of Ray Gimmey. Schroeder has leapfrogged three places to sixth. Mozer, who barely avoided ditching in a lake on the way back—"I was going to find out if these things float"—is still in fifth place.

In the evening the word is out that despite the race's pick-your-own-course format, Schroeder and Chenevoy followed identical routes for their trips. In Europe, team flying—where several pilots fly side by side to seek out lift, like beaters flushing grouse out of the brush—is fair practice. In the United States team flying, though not illegal, is considered bad form. No one can prove that Schroeder marked thermals for Chenevoy, thus ensuring his friend's hold on first place, but there are mutterings. After a private meeting with the race director the next morning, Chenevoy emerges dark-faced and tight-lipped.

For the final race the pilots line up their sailplanes at noon along the edges of the runway in double-file and wait for the towplanes to start up. A sparse crowd of tourists has emerged from campers and vans, loaded with videocameras. There is a delay as a business jet taxis by and the pilots rush to hold their wingtips steady in the jetwash. As the Gulfstream thunders off, the competitors wince and cover their ears. George Lee criticizes the pilot's takeoff and the sailplane pilots nearby agree as they wipe invisible soot from their wings. Surely they could fly the jet better than *that* pilot did. Lee, in fact, flies Cathay Pacific Boeing 747s out of Hong Kong when he's not soaring. But that's just a job. The consensus among sailplane aficionados is that powered flight is just "boring a hole through the sky." As a sporting challenge, they rank it just above driving a station wagon.

The day's race, a routine triangular course to Avon Park, Clermont, and back to Winter Haven, is anticlimactic. The leaders fly defensively, keeping an eye on those next on the point scale. With everyone flying the same short course today, team flying is not an issue. Schroeder and Chenevoy wait for a late start, then take advantage of two unexpectedly strong thermals to catch up to the pack at the first turnpoint. Schroeder ends up swooping around the course at 75 mph, the best speed yet. Chenevoy starts and finishes at virtually the same time as Schroeder, snaring second place for the day and winning the tournament.

The mood after the race is upbeat. "Bruno, congratulations," Mozer tells runner-up Gantenbrink, who has a roomful of trophies back in West Germany to console him. "At least you beat all the world champions." ✈

On the Road to Io

A probe called Galileo may soon watch Jupiter put the squeeze on one of its moons.

by Thelma Chang

Illustrations by Ron Miller

The images were startling. During rapid hit-and-run flybys of Jupiter in 1979, cameras aboard the two Voyager spacecraft witnessed at least eight volcanic eruptions on the surface of Io, one of the giant planet's moons. The volcanos spewed forth huge umbrella-shaped plumes, one at least 180 miles high and 720 miles wide. Boiling sulfur pits dotted Io's surface, colorful lava flows poured from volcanic craters called calderas, and gaseous sulfur dioxide appeared over one volcanic area. Io, the most geologically active body in the solar system, was soon being compared to Dante's Inferno.

Although some observations of Jupiter's moons had been made from Earth and the Pioneer spacecraft, little was known about them until the Voyager missions. The four largest, discovered by Galileo in 1610 and known as the Galilean moons ever since, revealed their individual characters in 1979. Europa is covered with a crust of ice resembling a cracked eggshell, which suggests the presence of liquid water beneath. Ganymede has mountains and valleys and exhibits evidence of plate tectonics similar to Earth's continental drift. Callisto, the farthest of the four from Jupiter, is apparently a cold and barren world. Io, the closest to Jupiter, is mottled red and brown and about the size of our moon. It is the only body in the solar system besides Earth known to exhibit volcanism. (However, there is evidence of volcanic activity on Venus.)

Scientists hope that investigations of Io's volcanic activity may shed light on Earth's own volcanism. They look to another Galileo—this one a spacecraft—to fill in some blanks. Scheduled for launch from a space shuttle in October 1989, Galileo will operate within the Jovian system for nearly two years, skimming 20 to 100 times closer to the moons than the Voyagers and scrutinizing the giant planet and its "miniature solar system" as never before. Technologically superior to the Voyagers, Galileo carries 11 scientific instruments on its orbiter portion and six others on a probe that will provide the first direct sampling of Jupiter's atmosphere.

While the Voyager observations functioned as quick snapshots, Galileo will provide long-term views of Io's volcanos. "You want to know how this all fits into a longer history," says Jay Goguen, resident research associate at the Jet Propulsion Laboratory in Pasadena, California. "For example, Voyager I and II took pictures of the volcanos just four months apart, but even within that short time, Pele, one of the largest ones, had shut down and stopped .... And also there was evidence observed by William Sinton [of the University of Hawaii] that in the period between the two Voyagers there was an eruption that turned on, did its thing, then turned off. When Voyager II got there, you could see a dark spot and a big bright halo, which looked much like other volcanos."

Galileo's first task is to leave Earth, something that has proved frustratingly difficult. Originally it was to be launched by shuttle in 1982, boosted out of orbit by an Inertial Upper Stage, then slung

MICHAEL CARROLL

Galileo will use Io's gravity as a brake, then move on to escape Jupiter's intense radiation field (right).

Viewed from Europa, Io is dwarfed by Jupiter. Galileo can observe the satellite even from this distance.

Galileo's probe will sample Jupiter's gases before being crushed by the increasing atmospheric pressure.

to Jupiter by a gravity assist from Mars. When that schedule slipped, Galileo's new launch window required a more powerful upper stage, the Centaur.

When *Challenger* exploded, not only was Galileo stranded, but post-accident rethinking led to the abandonment of the liquid-fuel Centaur. Reteamed with the Inertial Upper Stage and unable to use Mars for a helping hand, Galileo needed to find a new route to Jupiter. The result will be an elaborately meandering journey called VEEGA (Venus-Earth-Earth-Gravity Assist), a form of celestial pinball among the planets.

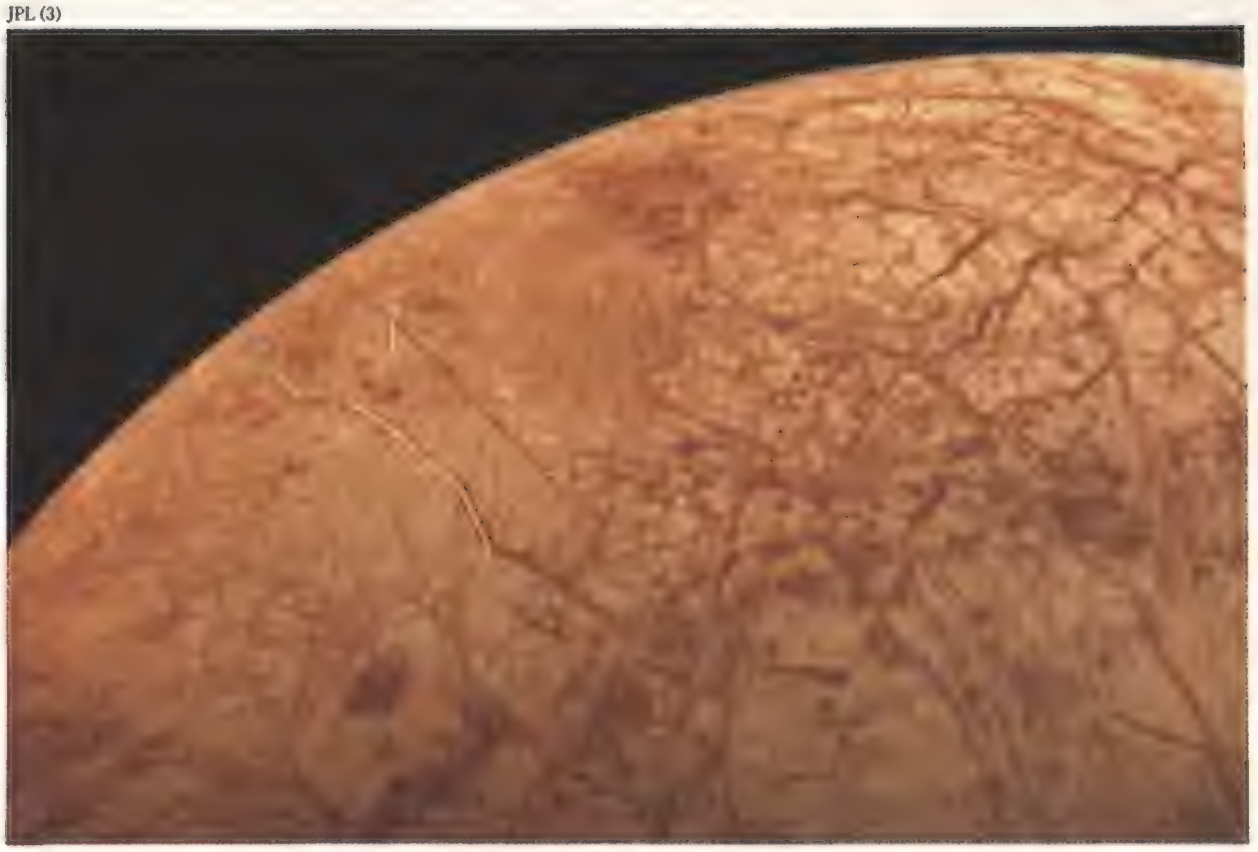
VEEGA makes for an ingeniously plotted itinerary. Once in Earth orbit, Galileo will be boosted not to Jupiter but to Venus. There, the planet's gravity will slingshot the spacecraft back to Earth for another boost out to the asteroids. Two years later the spacecraft will intercept Earth's orbit again for a final assist to Jupiter. The journey will last six long years, but its benefits include opportunities to scrutinize asteroids and the far side of the moon.

As the orbiter reaches the Jovian system it will fly within 600 miles of Io, a maneuver intended to brake the spacecraft for insertion into orbit around Jupiter and allow it to listen as its probe enters the Jovian atmosphere. Galileo will make its most intensive studies of Io at this point, says Fraser Fanale, the spacecraft's satellite working group chairman.

Fanale works out of a library basement that houses the planetary geosciences division of the University of Hawaii's Institute of Geophysics. Pictures of Galileo cover a wall. One diagram shows the spacecraft skimming Io's surface at volcanic plume height, a feat the diagram describes as "shooting a bullet within one bullet width of another bullet at a distance of 25 miles."

Galileo can't loiter in Io's neighborhood, however: at that distance Jupiter's intense radiation would soon prove deadly. "We'll get most of the intensive Io data within hours of the [one] encounter," Fanale says. "But even when we're not dealing with Io—say we're at Europa's orbit doing something else—we can make observations of Io as well as Voyager did." Once inside the Jovian system, Galileo will sweep past the outer moons on a route that takes in 12 looping encounters with Europa, Ganymede, and Callisto. "My job is to make sure the project does all these encounters with the best coverage and resolution," says Fanale. "Different distances are sometimes better for different things . . . . For [wide-area] coverage you want to be far away. For high reso-

JPL (3)



The Voyagers provided glimpses of the other Galilean moons. Europa (top) is small and icy, Callisto (middle) is cold and barren, and Ganymede shows signs of continental drift.

lution you want to be close. For an occultation you have to be behind the planet. For morphology you want shadows. But the guy who wants a compositional angle, the last thing he wants is shadows. He wants flat lighting."

Fanale has especially high hopes for Galileo's high-resolution camera, the near-infrared mapping spectrometer (NIMS), which he describes as "a marriage of a spectrometer and an image system." Each pixel—one of the many elements that make up a NIMS image—includes both visual and spectrographic information. "You can either slice it one way or slice it another," says Fanale. For example, a scientist can take a NIMS image and have a computer color-code the pixels that have recorded, say, sulfur or basalt. He could even create a false-color image that color-codes every substance pictured. "With NIMS we can actually see a compositional image," Fanale says. "That's a very powerful technique that can do, in about half an hour, the work of 100 geologists working 100 years in the Andes. We're looking at Io with something that can measure while it's imaging."

Galileo's observations could lead to a better understanding of volcanism on our planet. In our few thousand years of recorded history Earth has never experienced Io's level of volcano activity. Enormous eruptions may have occurred earlier, however. For example, the Kimberly diamonds, from a volcanic vent in South Africa, must have been formed under great pressure deep inside the ground, then forced to the surface by a tremendous eruption.

"There are periods on Earth when volcanism is active and not so active for reasons we don't fully understand, so it's important to see if those irregularities in activity level also exist on Io," says Thomas McCord, Galileo scientist and chairman of the geosciences division of the Hawaii Institute for Geophysics. "Then, if we find another planet with this characteristic, we can compare it to Earth to better under-

stand the volcanism process."

We do know that Earth's volcanism results from interior heat created by the radioactive decay of such elements as uranium, potassium, and thorium. The heat generated through such processes should be roughly proportional to a planet's volume—yet Io, though much smaller than Earth, has more intense interior heating. Scientists believe that proximity to Jupiter may partly account for this.

There is general agreement that Jupiter exerts tidal forces on its satellites and that the friction caused by the tides creates heat. Io, the Galilean moon closest to the planet, is not only especially susceptible to the gravitational effects of Jupiter, it also feels the tug from the outer moons. Io is continually squeezed by a process called tidal flexing, much like being held in a fist that keeps tightening and relaxing.

"That's what provides the heat on Io," says the University of Hawaii's Sinton. "Io is just about the distance from Jupiter as our moon from Earth. But Jupiter's mass is 318 times greater than Earth's, and on Io the tides are that much stronger. More than that, Jupiter's gravity causes Io to move around it in 1.7 days, much faster than the 28 days it takes our moon to move around the Earth. So not only is Io getting squeezed, it's getting squeezed faster and that heats it up even more."

The huge plumes spewed from Io's volcanos, especially the spectacular 180-mile-high plume above Pele, indicate the extremes of Io's volcanism. Sinton, who has studied Io for eight years to gather data on a massive lava lake named Loki, points to a picture on his wall of Mount St. Helens smothered by a cloud of cinder and ash. "If we imagine that we took away the Earth's atmosphere and a lot of its gravity," he says, "that cloud would rise substantially higher," though not nearly to the height of Io's plumes. The scientists studying Io hope that once they have identified the eruptions' composition they can begin to understand the mechanism that hurls them so high.

There are two candidates for the materials involved in the volcanism: silicate—molten rock like Earth lava—and liquid sulfur, which is not as common on Earth. Sulfur has been detected on Io,

Squeezed by gravity from Jupiter and the outer moons, Io releases interior heat through volcanism.

but some believe that it may not be as common as silicate, existing mainly like "paint on the surface," according to Robert Howell of the astronomy and physics department at the University of Wyoming. Favoring the silicate argument are recent observations by a Jet Propulsion Laboratory group, which detected a volcanic explosion that was too hot to be liquid sulfur. Furthermore, fluid sulfur would be unable to support the mountain ranges seen on the satellite. A point in favor of the sulfur, however, is the fact that Io is so dry. "Once you get rid of water," Howell says, "sulfur is one of the things left that is volatile." Most likely, both types of eruptions are present on Io.

Another puzzle is Io's torus, a doughnut of glowing ions—charged particles—that accompanies Io in its orbit around Jupiter. "It may be that the volcanos provide the atoms to the torus," says Jet Propulsion Laboratory's Jay Goguen. "The material comes off Io's surface by impacts of energetic particles . . . . It's hoped that by watching the volcanos and the changes in the torus you can demonstrate a link between vol-

canic activity and the source of materials in the torus."

Periodically, project scientists have observed Io from facilities located, suitably enough, atop another volcano—Mauna Kea, on the island of Hawaii. (At 13,796 feet, Mauna Kea's summit is above 40 percent of Earth's atmosphere, so its telescopes are especially sensitive.) Even from the most powerful telescope, Io appears as a mere pinpoint of light, but with the help of computers and special filters scientists have been able to make some observations. "One of the most important factors about this research is to find out where the erupting volcanos are so that Galileo will know where to point the cameras," says Goguen. "It's also important to look at Io [from Earth] at the same time Galileo is looking at it because you want to know how ground-based measurements relate to what the spacecraft is seeing."

Other Earth observations will help. Scientists worldwide are organizing an International Jupiter Watch to coordinate Earth-based observations with Galileo's. "We want to have coverage of Io, Jupiter, and the whole system not just from one location on Earth but from such places as Australia, Chile, the Canary Islands, Japan, the U.S. mainland observatories," says Sinton.

In 1991 scientists can also take advantage of an occultation, a relatively rare occurrence in which Earth is in a position to observe one satellite cover up another and the moons' paths appear "edge on." When one satellite's edge crosses a volcano there's a sudden drop in reflected light, allowing astronomers to measure the volcano's size. Meanwhile, Mauna Kea's 10-meter Keck telescope, the largest of its kind, is scheduled for completion in 1991.

Io's volcanism is, of course, only one facet of the Galileo project, which employs an estimated 700 people, including engineers, managers, technicians, and 115 renowned national and international scientists who make up 17 different investigation teams. Despite delays, they've weathered the disappointments and continue to pull it together. Jet Propulsion Laboratory's Torrence Johnson, chairman of the Galileo Project Science Group, is responsible for coordinating the craft's 17 onboard investigations involving six nations, a job not unlike that of an activities director on an ocean cruise. "It's interesting in that you have to be worried about looking at all aspects of the Jovian system at once," says Johnson, whose youthful appearance belies the fact that his experience extends back to the Voyager project. "While we're dealing with people from all over, it's without conflict because the culture is one of scientific experiments, so we share the same wavelength in that respect. We worry about the right measurements, the right everything."

"I, as an investigator, probably spend about three solid months each year simply planning the mission," says Thomas McCord. "There are dozens of investigators who spend various amounts of time. It comes out to hundreds of years of effort, and that's just the science."

Galileo's delays have been frustrating for its investigative team: by the time Galileo returns its data in 1995, about 20 years will have gone into the project. William Sinton will have retired from the university system by then, and others may not be around for the payoff. "One investigator from California has already died," notes Fanale. "[But] even if we're not here, it's critical that we do a full-up beautiful mission because Galileo has an impact for all of us." ✈

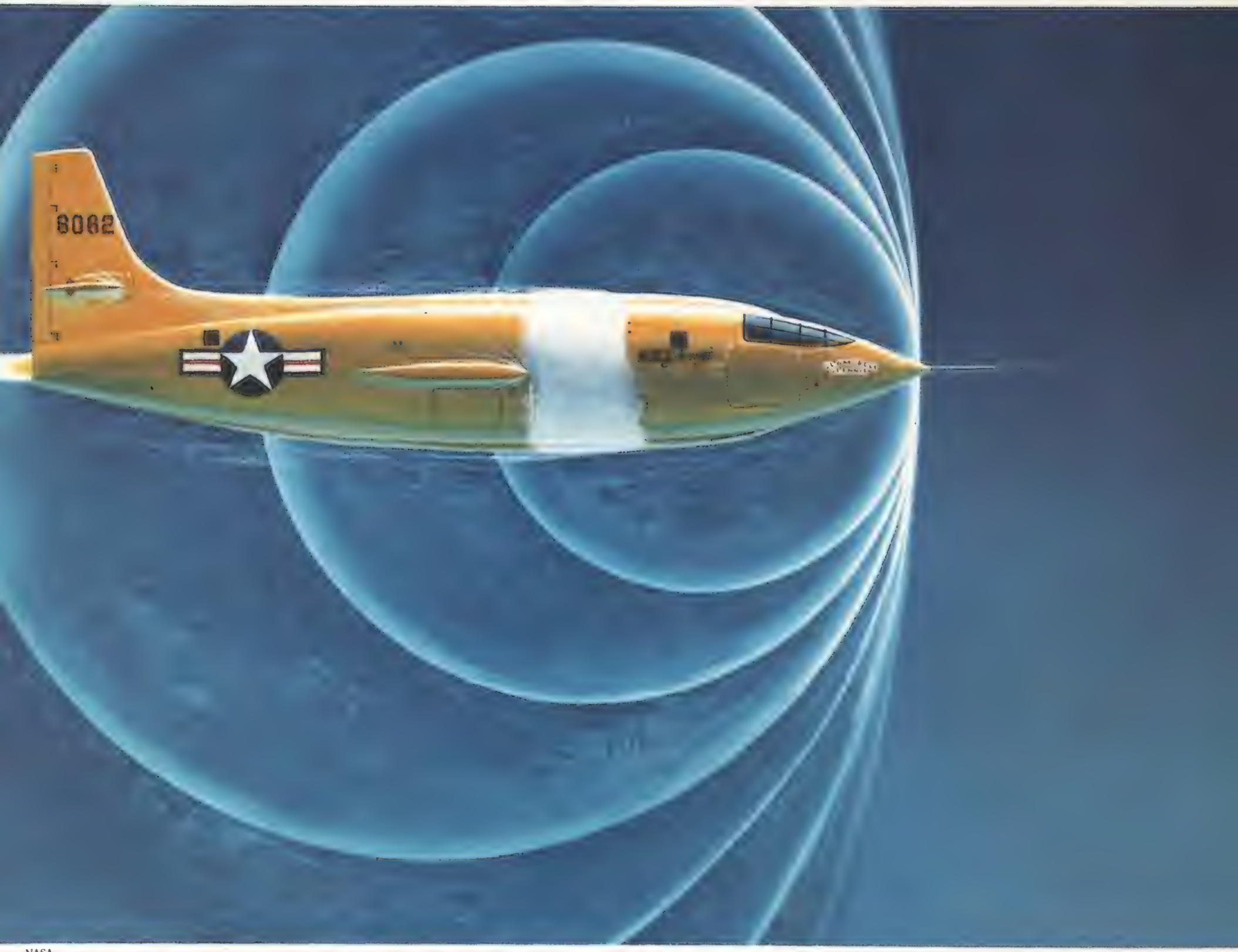
Bringing Up Betsy

What started as a hobby for four rocket fanatics went on to break the sound barrier.

by Frank Winter

NASM

A young Jimmy Wyld examines his first regenerative engine.



NASA

A 6000C4 rocket engine—familiarly known as Black Betsy—propelled the X-1 faster than the speed of sound.

On the morning of October 14, 1947, a bright orange Bell X-1 transcended the speed of sound, sending the very first aircraft-generated sonic boom over the Mojave Desert and putting another name on the roll of aviation's greats. That the name was Chuck Yeager, the X-1's pilot, rather than, say, Lovell Lawrence, or Hugh Franklin Pierce, John Shesta, or Jimmy Wyld, is something few would question. But behind the speed of the bullet-shaped aircraft, and literally behind Yeager, was the rocket engine that made it all possible. And behind that 210-pound, four-chamber engine were Lawrence, Pierce, Shesta, and Wyld.

Men of distinctly different temperaments, the four founders of Reaction Motors, Inc. (RMI), the company that designed and built the engine, had little in common save a burning interest in rocketry. Their paths converged with membership in an organization of devoted amateur rocketeers, the New York-based American Rocket Society. Afterward, the path they chose to follow—the path that led to their innovative engine—passed through largely uncharted territory.

Rockets were nothing new—they had been around since the Chinese discovered the propellant qualities of gunpowder a thousand years earlier. But most were little more than fireworks or crude weapons of warfare. At the end of the 19th century, a partly deaf Russian mathematics teacher, Konstantin Tsiolkovsky, theorized that liquid fuels offered far greater energy per kilogram than solid fuels, burned longer, and were controllable. He demonstrated mathematically that liquid-fuel rockets were capable of speeds up to escape velocity (24,000 mph), which would permit them to leave Earth orbit. Before World War I, U.S. physicist Robert H. Goddard made similar calculations independently and began experimenting with liquid-fuel rockets. Unfortunately, Goddard's experiments were reported only superficially in the newspapers and Goddard himself was secretive about his work. Amateurs like the experimenters of the American Rocket Society were largely on their own.

Of the four RMI founders, the company's president—suave, gregarious Lovell Lawrence Jr.—had the most prosaic background. Known by the nickname "Bunny," or "Bun," Lawrence was the son of a mining engineer. He had been in love

NASM

Using one of Shesta's test stands, members of the American Rocket Society fire a rocket engine in a New Jersey field.

with machinery since childhood and was an imaginative tinkerer whose inventions ranged from cigarette lighters to electrically heated suits. Unable to complete his college education during the Depression, he worked briefly as a surveyor, then sold real estate before landing a steadier, more appealing job in 1934 constructing and testing radio transmitters for a growing young company called International Business Machines.

Two years later, Lawrence was bitten by the rocket bug and joined the American Rocket Society. Although not an active experimenter, he had organizational talents that got him quickly installed as the club's secretary, then president.

In marked contrast, RMI's first vice president, Hugh Franklin Pierce, was an unpolished, hard-drinking, former New York City subway ticket-taker. Before that he'd been a sailor—and he had the tattoos to show for it. Still, he had been one of ARS's earliest members, having joined in 1931, a year after it was founded. His chief asset to the club was not his Navy machinist's training (a course he dropped before completing); it was the lathe and other tools he had in his Bronx basement shop.

Pierce's handiwork—and the grand sum of $49.40—was largely responsible for the society's first rocket, built the year after he joined. It had a sheet-tin body and fins, a silk pongee parachute from the five-and-dime, and a parachute container made out of a cocktail shaker. Pierce himself fashioned the battery ignition system and threw the switch for the first test, conducted in a field in Stockton, New Jersey. The modest liquid oxygen-gasoline engine produced a bluish white sword of fire for a few seconds, followed by a shower of flames that damaged the engine and scorched the surroundings.

Although the rocket never flew, Pierce remained one of the ARS's most active experimenters. Like Lawrence, he became one of the society's presidents, but his bad spelling and atrocious grammar proved an embarrassment to the members.

Another RMI founder—and its first secretary—was tall, taciturn John Shesta. Born Ivan Shestacovsky in 1901 in Saint Petersburg (later Leningrad), Russia, he was the son of a purchasing agent for the Imperial Russian Government. On a trip abroad to purchase munitions during World War I, Shesta's father decided not to return to Russia, probably because of severe reversals suffered by the Russian army and chaotic conditions at home. The family joined him in the United States and settled on a chicken farm in a small Russian community in New York's Catskill Mountains.

The young Shestacovsky discovered rockets in this unlikely location. As boyhood amusement he built his own, one a partly plugged brass tube filled with gunpowder ground with a mortar and pestle. He made another rocket out of a grease gun.

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The young RMI had its own truck but no test stand. The company borrowed one from the rocket hobbyists.

When it exploded, the hobby ended—for a while.

After changing his name and earning degrees in mechanical engineering and chemical engineering from Columbia University, he briefly taught surveying, then held various engineering jobs. A devoted reader of the stories in science fiction pulps, Shesta learned of the American Rocket Society around 1933 through a Columbia classmate who was a member. He joined and started building rockets anew, this time with liquid fuels, which were easier to control than solid fuels like gunpowder.

One of his efforts, the society's fourth rocket, was among the few that really flew. It soared to an estimated 382 feet at 680 mph—near Mach 1—but descended less gloriously, landing with a huge splash in the water off Staten Island's Marine Park.

In the long run, Shesta's most important contribution to the ARS was one that didn't fly: in 1935 he made the society's first static test stand in his machine shop. The test stand permitted rocket engines to be fired and tested in place, which cut the expense of building rockets—a real boon in those Depression years. Members could also learn much more about their rocket engines by closely observing them firing on the stand as gauges marked thrusts and pressures.

Probably the oddest of RMI's founders was its director of engineering, James Hart Wyld. Moody and brilliant, he walked with a limp (nobody knew why, though some rumors blamed a neglected case of athlete's foot), his eyes cast down, and constantly kept a pipe in his mouth. "Brainy" and "always thinking," one RMI old-timer described him.

Of Scotch-Irish ancestry and the son of a mechanical engineer, Wyld was a prodigy who learned to read largely on his own at age four and proceeded to read the 20-volume *Book of Knowledge* cover to cover several times.

Wyld's parents recognized his gifts and provided him with a private tutor for three years. He attended prep school, then entered Princeton, where he graduated with high honors in 1935 with a bachelor's degree in mechanical engineering. Princeton also bestowed a Sayre Fellowship in Electrical Engineering. But Wyld's interests and abilities were eclectic. He was adept at writing (both prose and poetry), languages, debating, acting, and sports. He also loved astronomy, airplanes, and magic and was, according to the pages of his diary, a sensitive, self-conscious person, tormented through his school years with indecision about his future. At one point he contemplated writing the definitive book on magic. Then, in 1935, as his diary relates, his life was "completely changed around."

Young Jimmy read an article in the *New Outlook* magazine that described the American Rocket Society and gave thumbnail sketches of the day's leading rocketeers. He looked up the society in the New York phone directory and soon, he later recalled, "was deeply engrossed in the Society's early experimental tests . . . ." At last he had found a challenge for his considerable technical abilities, intellect, and energy. The field was still new, he wrote, "and there are so few people working on the thing that you might be able to do some really original work . . . ."

Techniques of experimenting with rockets were still fairly primitive then. The greatest hurdle experimental rocket builders faced was developing a method for cooling the engines. Without effective cooling, rockets overheated and blew up. Wearing protective World War I surplus helmets and crouching in the fields, the rocketeers would stare intensely at the flames from the engines and dials on their static stands for signs that their various cooling systems were breaking down—while also keeping a sharp watch for bothersome policemen or fire marshals.

The ARS experimenters had tried to cool engines with water jackets, aluminum "heat sponge" blocks, heat-resistant materials such as Nichrome, and cooler-burning fuels. Water-cooling, they quickly found, had limited value. It worked on smaller engines but was too heavy and ineffective for larger rockets. Aluminum blocks were cumbersome. Heat-resistant materials would not survive under long runs. The most promising technique appeared to involve cooler-burning fuels. Alcohol burned more smoothly than gasoline and when diluted with water, it cooled the engines a tad.

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Engine testing in RMI's early days—here, a single 1,500-pound-thrust chamber—was a crude and risky business.

Meanwhile, Jimmy Wyld, then a Princeton senior, had in his exacting, extraordinary way begun a thorough survey of all the technical rocket literature he could find. He and another student also obtained the use of a basement workshop in Princeton's Astronomical Observatory for proposed rocket work (but were issued the reasonable warning *not* to shoot off rockets inside the building). Here, he and his fellow rocket fanatic started making parts for a rocket they hoped one day to launch in Princeton's stadium. Perhaps it was just as well that the grind of school work and a tight allowance put a stop to their plans.

During breaks, Wyld returned to his rocket books and his characteristically prolific letter writing—on long, yellow pads—to his new ARS friends. In late 1935, one ARS colleague introduced him to the work of Austrian rocket experimenter Eugen Sänger (see "The High-Flying Legacy of Eugen Sänger," August/September 1987), and Wyld discovered what seemed a more promising idea: regenerative cooling. Wrote Sänger in 1933, "the propellants themselves must be used to cool the engine . . . ." One or both propellants were to circulate around the combustion chamber prior to injection for

BARRETT GALLAGHER/FORTUNE MAGAZINE (2)

In its early stages of development, the Black Betsy belched and groaned, but it worked.

Three of RMI's four founders—from left, Shesta, Pierce, and Wyld—gather around their most famous creation.

ignition. This would both cool the engine and pre-heat the fuel for smoother burning.

With a burst of feverish calculations, Wyld worked up his own design, and soon the project became an obsession. After graduation, he and his Princeton friend took a holiday in England. P. E. Cleator, founder of the British Interplanetary Society, took them to North Wales to see the ruins of King Edward I's magnificent castle. But Wyld seemed oblivious to these grand sights and instead, as Cleator remembers, "regaled us with an account of his plans for a regenerative motor . . . ."

Construction of the engine began in 1937. Wyld was then rooming with two electrical engineers in Greenwich Village. The trio were, in Wyld's words, "violent gadgeteers" and had fixed up a six-foot-square workshop in an adjacent pantry. Construction started out slowly but speeded up in the recession of 1938 when Wyld lost his job, giving him plenty of time

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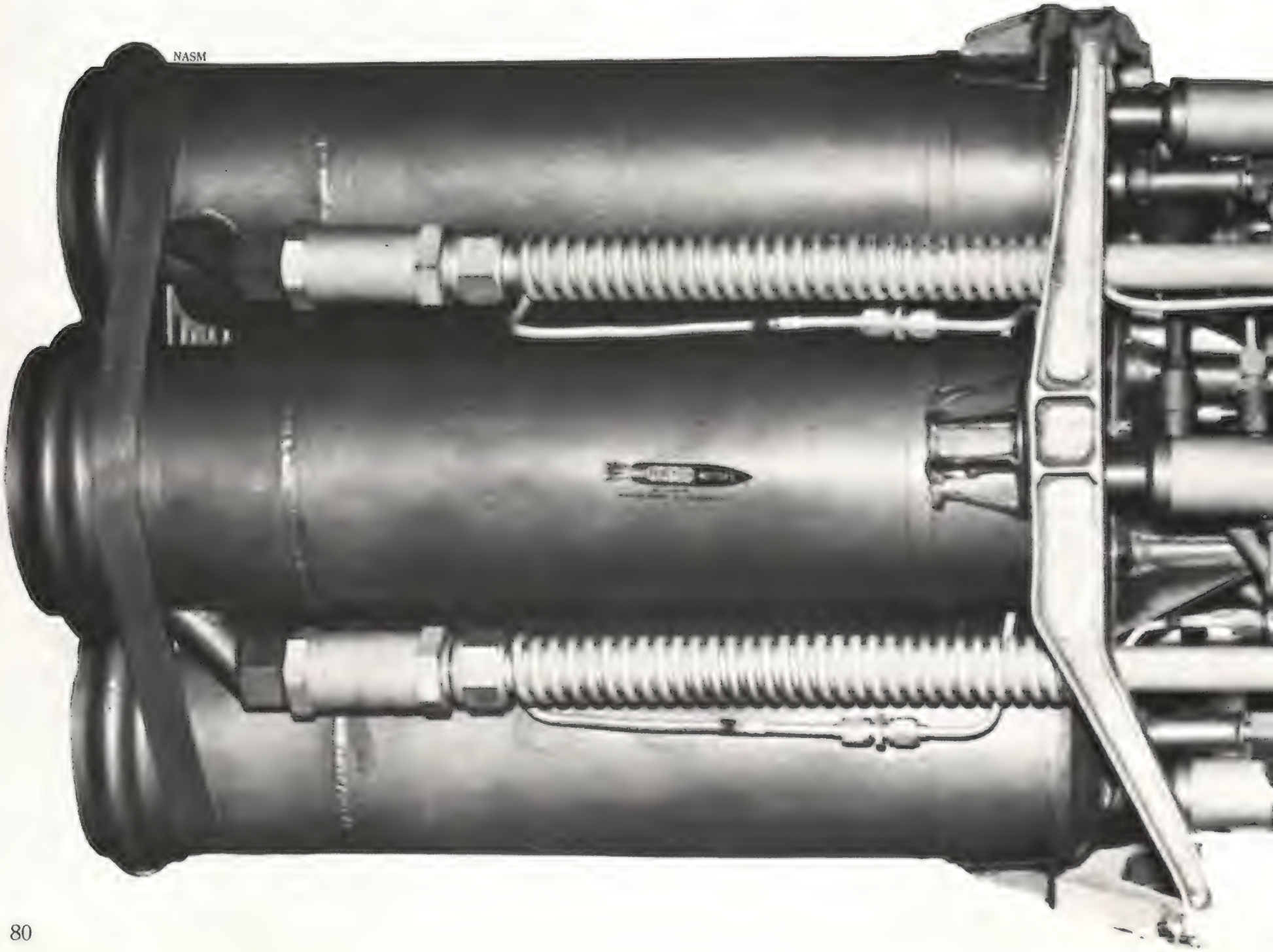

for rocket projects. The same thing happened to John Shesta, who was using his new-found free time to build a new test stand. Wyld subsisted on chop suey and spaghetti, Shesta on rye bread and lard.

While Shesta put the finishing touches on ARS Test Stand No. 2, Wyld, in his closet-like workshop with his roommate's nine-inch South Bend lathe, completed his first regeneratively cooled engine. Generating 100 pounds of thrust, it weighed a mere two pounds and could be held in one hand.

Wyld's engine made its firing debut on Shesta's new test stand the morning of December 10, 1938, on a lot in New Rochelle, New York. The next day Wyld wrote one of his marathon letters to another ARS friend to report some good news. He had not found a job, he reported, but "my regenerative motor . . . proved a most striking and unequivocal success" and demonstrated the regenerative principle "beyond any possible doubt." Fueled with liquid oxygen and alcohol, the engine ran for 14 seconds and showed no signs of heat damage. The heat barrier had been broken.

Wyld's finances did not fare as well. Broke, he settled for a job with a boilermaker in Massillon, Ohio. He later found a more interesting position at Langley Field, Virginia, working on the high-speed airfoil wind tunnel developed by NASA's precursor, the National Advisory Committee on Aeronautics. After earning enough money to pursue his passion, he returned to New York in the summer of 1940 and began refining his little engine. He successfully tested it again—for up to 40 seconds—in June 1941.

That fall, Lawrence, Pierce, Shesta, and Wyld decided to

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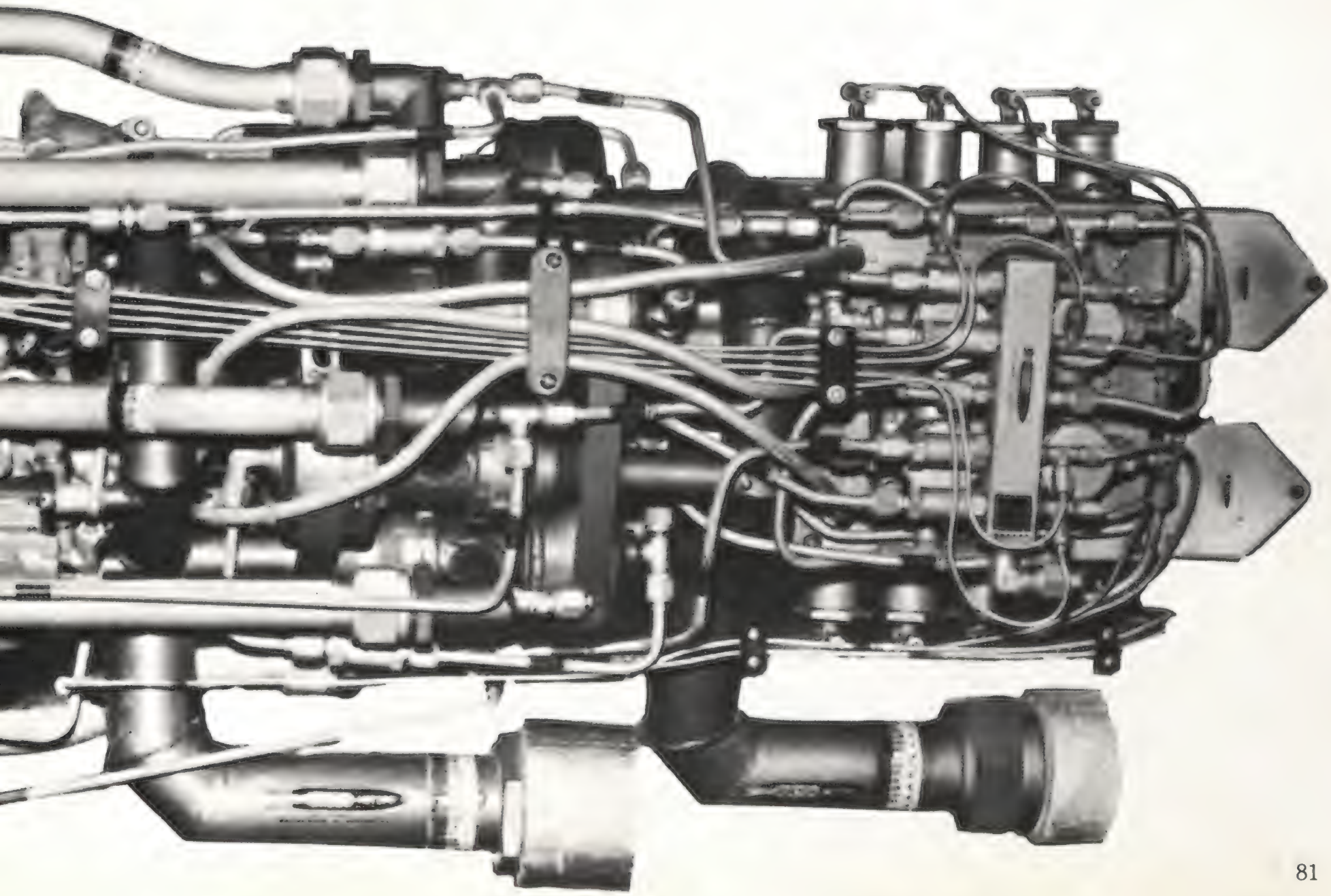
One of the three first-generation X-1s shows its stuff in an early 1947 test at Bell's Niagara Falls facility.

If beauty is in the eye of the beholder, then Betsy was probably gorgeous to engineers and test pilots.



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Hydraulic lifts lower a B-50 over an X-1, which was dropped directly into flight from the Superfortress.

form a company. Wyld baptized it Reaction Motors, Inc., a play on General Motors. He wrote that America's first commercial liquid-propellant rocket company "scarcely had two nickels to rub together." Borrowing $5,000 from friends and family, the foursome set up shop in Shesta's brother-in-law's garage, "big as a spacious outhouse," in North Arlington, New Jersey.

Bun Lawrence could see war coming and thought that the government could use the engine. Then temporarily assigned to the Army Message Center in Washington, D.C., to install an IBM teleprinter, Lawrence put Wyld's engine in his briefcase and brought it around to Navy officials. Soon, a Navy lieutenant was sent to the secluded woods of Wanaque, New Jersey, to watch a test of the engine. It was another success.

Wyld went to Shesta's home one or two Sundays later and began writing up the test results to the sound of music blaring over the radio. Suddenly, the program was interrupted by a news bulletin. Pearl Harbor had been attacked.

Overnight, the Navy *really* became interested in rockets, though not as weapons. In a few days RMI received its first contract. The Navy wanted the company to develop liquid-fuel Jet-Assisted-Take-Off (JATO) rockets that would help heavily laden seaplanes shorten their takeoff runs. Based on Wyld's little engine, the JATOs were scaled up to 3,000 pounds of thrust and by 1943 were making their first successful trials.

RMI grew from a borrowed garage to a new plant at Pompton Plains, New Jersey, with a concrete blockhouse (still standing at Franklin Lakes, and now a national landmark) for protected viewing of engine tests. The plant was a former silverware factory that had been converted into the Silver Circle nightclub. It still had bar stools in place when RMI moved in.

America soon had a second liquid-fuel rocket company: on the West Coast, Aerojet, Inc. was launched a few months after RMI by California Institute of Technology engineering students under the mentorship of famed aerodynamicist Theodore von Kármán and was also making JATOs. (They had great success with their simpler and cheaper solid-fuel versions.)

Better funded than RMI and also highly competent, Aerojet won the contract for a 200-pound-thrust engine fueled by nitric acid and aniline for the United States' first rocket airplane, the small, experimental Northrop MX-324 flying wing, a prototype for a larger flying wing interceptor, the Northrop XP-79, which would have an engine ten times more powerful.

The MX-324 made secret subsonic flights in July 1944, but the project survived neither delays nor the end of the war and was canceled. The 2,000-pound-thrust "Aerotojet" intended for the XP-79 did survive, however. When Major Ezra Kotcher began spearheading the idea of a U.S. Army Air Forces airplane to probe the feared "impenetrable supersonic barrier,"

he had the Aerotojet in mind. Although he was unaware of RMI's work, Kotcher knew that the Aerotojet's propellants were hardly optimum choices for a manned research aircraft. Nitric acid and aniline are hypergolic—that is, they ignite on contact. This did away with the need for an igniter but increased the chances of an explosion. Furthermore, the acid produces toxic fumes and is highly corrosive.

In February 1945, the X-1 rocket plane contract was awarded to Bell Aircraft. With a healthy distrust of hypergolics, the Bell designers purchased a bottle of each of the two propellants, taped them together, then threw them against a rock to see the hypergolics do their thing. The resulting fireball was convincing.

RMI, meanwhile, had been awarded another Navy contract that must have sounded like a fantasy come true to its four founders: it called for the development of an engine to be used in the Navy's supersonic airplane program. X-1 design engineer Benson Hamlin discovered RMI by chance around this time. He saw the possibilities of Jimmy Wyld's reliable, non-hypergolic engine, now refined and scaled up in preparation for the Navy's program (the ultimate product of which was the Douglas D-558-2 Skyrocket, which materialized somewhat later than the X-1).

In a spirit of wartime cooperation, the Navy's Bureau of Aeronautics agreed to release the engine to the Army Air Forces. RMI was awarded the X-1 powerplant contract in April 1945. At the time, the company employed 35 people.

In those exciting years, the RMI family was a very informal one, with no time clocks and high morale among the mainly young staff (the average age was 26). Design modifications and technical problems were often worked out over lunch or a late dinner at the Triangle Grill when RMI was at Pompton Plains. Then they would all go back, recalled former shop foreman Lou Arata, "and work like hell, sometimes until 9, 10, or 11 at night. Sometimes John Shesta would also come around with a clipboard and make modifications on the spot."

Lawrence, Shesta, and Wyld (but probably not Pierce) had already been doodling with rocket plane ideas. One sketch from Lawrence's notes, dated January 1945, shows a proposed rocket interceptor propelled by four 750-pound-thrust engines. This may have been the genesis of the idea to take four modified 1,500-pound-thrust engines and bind them together to make the X-1's four-barrel engine.

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When the X-1 was donated to the National Air and Space Museum in 1950, Yeager and curator Paul Garber admired its powerplant.

Kotcher came to RMI to see if the weird four-cylinder rig was really feasible. To dress it up, RMI had painted it black, but the engine made such a hideous noise when it fired that the RMI boys affectionately called it the "Belching Black Bastard." Later, the name was cleaned up for the press to "Black Betsy," in part after Lawrence's three-year-old, Betsy Ellen. "Betsy" also implied reliability, like Davy Crockett's rifle, Old Betsy.

"Surprisingly," says project engineer Jim Fitzgerald, "there were no major accidents in the development of the engine, yet testing means were very crude by today's standards. It was hellishly dangerous. The firing room, an unprotected quonset hut [for viewing the tests], was only 20 feet away from the test stand. Had the engine blown up it would have come right through."

Designated by RMI as the 6000C4—the number 6,000 stood for the pounds of thrust provided by the four chambers—it was then the only engine capable of such high performance for its weight. No reciprocating engine approached it in terms of horsepower: the RMI rocket, also known as the XLR-11, its Air Force designation, generated about 10,000 horsepower when it broke the sound "barrier" at 40,000 feet. Propeller airplanes were good only up to 500 mph, while the most powerful turbojets then available produced only 4,000 pounds of thrust. And the jets were ponderous, complex pieces of machinery, whereas the RMI powerplant had few moving parts. The individual chamber itself was similar to the one used in the original JATO tests.

Yeager's powerplant controls couldn't have been simpler: one ignition switch per chamber. In his words, "you'd hit the ignition switch that started the igniter of gaseous oxygen and alcohol. That would raise the chamber pressure and open the propellant valves letting the liquid oxygen and alcohol into the

On October 14, 1947, Chuck Yeager flew the X-1 through the sound "barrier."

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Two Black Betsies paired up to power the X-15 to new speed and altitude records during its first flights.

chamber. It gave you roughly 1500 pounds of thrust."

The first powered X-1 flight took place on December 9, 1946, but a loose igniter nut led to a fuel leak and fire. Fortunately the engine shut down. The press reported only pilot Chalmers "Slick" Goodlin's success in easily reaching 550 mph—about Mach .79. On another occasion, Fitzgerald went to Muroc, California, for 6000C4 field checks. He was aghast that one X-1 had landed with an entire combustion chamber missing and the injector plate "waving in the breeze. The pilot didn't even know it." He concluded, "We learned a lot from this. We had the engine X-rayed and made more precise welds from then on.... We were really very fortunate in this program."

Fortunate indeed. The hundreds of tests at all hours and Jimmy Wyld's volumes of calculations paid off. Black Betsy really did become reliable. Still, RMI continued to refine it.

The pumps that squirted liquid oxygen and alcohol into the combustion chambers was one area marked for improvement. At the start of the project, no lightweight pump existed that could move the liquid oxygen fast enough. Bill Munger, the RMI employee assigned the pump job, also had a hard time finding a gas generator to drive the turbine that powered the pump. So the first Betsies used pressurized nitrogen to force-feed the propellants, much the way Wyld's original engine worked. This system powered the *Glamorous Glennis* when Yeager hit Mach 1.06. After numerous pump blowouts, Munger finally found a safe and sure way to produce gas to drive the turbine. He utilized the decomposition of concentrated hydrogen peroxide activated over a catalyst bed, as the Germans had done with their wartime rocket airplane, the Me 163. (Munger says nothing was picked up from Me 163 technology, however, which was just as well: the Me 163 also employed the regenerative principle, but it used an inefficient and dangerous fuel that could ignite spontaneously. Several of the aircraft were known to have exploded in midair.)

The more efficient and reliable turbopump model of the 6000C4 powered the X-1A, X-1B, X-1D, X-1E, and versions of the Douglas D-558-2 Skyrocket, all of which exceeded Mach 2 (except the X-1D, which exploded after an early flight malfunction). The Air Force's first supersonic experimental combat fighter, Republic's XF-91, used a Black Betsy as an auxiliary powerplant for accelerated takeoffs, climbs, and supersonic operations. And when the big RMI Pioneer engine for the X-15 experienced developmental growing pains that caused delays, dual Betsies were substituted for the first 20 or so powered flights, resulting in yet more speed and altitude records.

RMI Founders: An Update

Lovell Lawrence Jr. remained with Reaction Motors, Inc. until 1951. He joined the Chrysler Corporation's missile division in 1954, where he worked on the Redstone vehicle, the rocket that carried Explorer 1 into space in 1958. In 1971 he died at age 55 of cancer, but up to the last he was tinkering with machinery, building his own hydrofoil.

John Shesta left RMI in 1952 and died in July 1987 at age 86 in his Vermont home. An avid skier, he had run a ski lodge for some years.

Jimmy Wyld died of heart disease in 1953. He was 41.

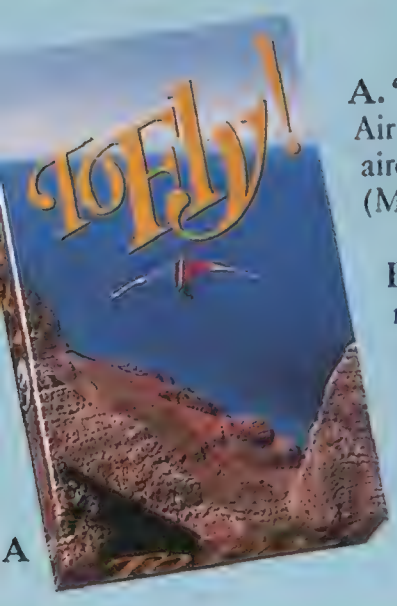
Finally, **Hugh Franklin Pierce**'s fate remains a mystery. Never an organization man, he sold his RMI shares in 1947, then departed for California, where he started a citrus grove. As Shesta recalled, the grove was destroyed by a severe frost. Pierce was never heard from again.

Reaction Motors, Inc. itself became a division of the Thiokol Chemical Corporation in 1958. The Reaction Motors Division was closed in 1972, having ceased to be a profitable arm of the parent company. Its properties were auctioned off.

Betsy was still going strong in the mid-1970s. NASA "Lifting Bodies," experimental wingless aircraft that eventually contributed to the design of the space shuttle—the MS-F3, HL-10, X-24A, and X-24B—were all powered with Black Betsies. And the present interest of Waldo Stakes of High Stakes Enterprises in Hesperia, California, may further delay its retirement; Stakes plans to use a single chamber from a Black Betsy, upgraded to 2,000 pounds of thrust, to set a supersonic land speed record over ice. According to Stakes, calculations indicate he should be able to attain a speed of Mach 1.26.

In the end, what was the secret to Betsy's incredible longevity and success? The engine was not a startlingly new concept in itself. But it was new in that it was safe and reliable, making the X-1 the first safe and reliable rocket airplane, something the craft proved again and again. The product of four unconventional men and one unconventional company, the Black Betsy was, simply, an engine that could—and did.

AN AIR & SPACE HOLIDAY



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HOLLY RUN

What's red and green and flies each Christmas?

by J. Forrister Ross

Illustrations by Maureen Tierney Carr

"Holly 1, this is Holly 2. Who the heck's that 150 butting in on final?" Ribbing one another over the radio, the pilots of our long curving procession of single-engine airplanes line up to land on the tiny seahorse-shaped island below. It's a Saturday morning in the middle of December and we are on a mission of Christmas goodwill, this one conducted by 32 pilots instead of three wise men.

We zip into final approach and it hits us all: the remoteness of Tangier Island, sitting 14 miles off the Virginia coast in the Chesapeake Bay. The isolation is even more impressive when you see how much of the island is unlivable—wet marshlands and sandy tidal flats. Several piers reach out to meet the water, but mostly it's water reaching into land, coursing through the flat terrain in small creeks and channels. The range of colors is narrow: white clapboard houses, green water, brown sand. No trees grow here. It's easy to see why this small community of watermen is so eager for the modest gift we bring—heavy-duty trash bags loaded with holly boughs.

Once on the ground the airplanes crowd the small parking area wingtip to wingtip. Edward Nabb, the 71-year-old Cambridge, Maryland lawyer who has organized our mission, is easy to spot: he's wearing a fire-engine red sweater and kelly-green pants. He grumbles something about that pushy Cessna, "probably some kid, maybe a little nervous, you know, he's probably used to landing at BWI [Baltimore-Washington International Airport]." Nabb says *he* learned to fly in a cow pasture.

We each drop our contribution on the growing pile of bags. Jimmy Simmons of Cambridge, dressed as Santa, has already headed off toward the Swain Memorial Methodist Church, surrounded by kids eyeing the lollipops and candy in his hands. Several of us stop to talk to Sherlou Pruitt, who teaches the island's 10 seventh graders. As her daughter, Carolyn, gazes about at the bags with a look of curiosity, the pilots who brought cameras snap the cute first grader's picture. Her mother tells us about the wedding that took place the weekend before. (This year's "Holly Run" was originally scheduled for the previous weekend, but Nabb, upon hearing about the wedding, rescheduled, not wanting to interrupt the all-island affair.) In the background, a group of little boys set off a string of firecrackers, a seasonal tradition on the island.

After a few minutes, the pilots wend their way down a narrow road and over a wooden bridge that crosses West Ridge Creek, where the skeletons of several long dead and weathered skiffs lie. The trail winds around a graveyard, and we notice that the old stones, many from the early 19th century, bear the same names over and over—Pruitt, Crockett, Parks, Dize. The markers seem to loom eerily, a consequence of a high water table that makes it next to impossible to keep anything well-buried. Puddles of rainwater drown the grass in a nearby backyard.

The main roadway is just large enough for a car to get through, though only the church's van, now full of bags of holly, drives past. The residents usually get around by foot, bicycle, or motorcycle, though several use gasoline-powered golf carts.

"It's another world," Nabb says when asked about his attraction to the island. Nabb first heard of Tangier from his father, a candy salesman who made stops there twice a year. When Nabb was 20 he paid his first visit, participating in a rescue effort in which he and several co-workers made daily supply runs to the island during a particularly harsh winter. By the time the airstrip opened in 1968, Nabb had made a couple of friends on Tangier. After several months of weekend sojourns, he says, the townspeople "didn't exactly accept me, but they stopped ignoring me."

Nabb has been making the 45-minute Holly Run from the Cambridge-Dorchester airport in Maryland ever since. The idea came to him one day while he was up at the family farm near the Transquaking River on Maryland's Eastern Shore. As he lopped branches off the holly trees to decorate his home, it occurred to him that his friends on treeless Tangier could use a few of the shiny green boughs. When he showed up with his bags of holly that first Christmas, the airport manager studied them awhile, then turned to Nabb and asked, "Friend, *what* do you say this green stuff is?"

As the Holly Run tradition evolved, Nabb found other pilots to accompany him, mostly from Maryland's Eastern Shore, but some from neighboring counties and even other states, such as New Jersey and North Carolina. The Ninety-Nines, a club of women aviators, are usually well represented, as are the Silver Wings, made up of pilots who soloed

at least 50 years ago. Nowadays, reporters from nearby newspapers and TV stations usually tag along—the Holly Run, after all, makes a great "Christmas spirit" story.

When we arrive at the Methodist church, Reverend George Close greets us on the steps and ushers us inside. Nabb joins him at the altar and the two men welcome the roughly 75 people assembled. Nabb nods to many of the regulars, then kids Dave Finlayson of Baltimore about his old Cherokee 140C actually starting up for two Holly Runs in a row. Then Nabb grows serious, pausing to pay tribute to an old pilot friend, a recently deceased participant. Not one to stay sentimental for too long, Ed adds, "You know he's gotta be crazy—he flew the Atlantic in a 172."

Reverend Close takes over, talking about last week's wedding, about our bringing holly, about his and others' caroling to the 15 island shut-ins. These things, he cautions, are nothing to God. He proceeds to deliver a sermon about Job and his victory, what true faith is. To his right is a large wooden plaque that says in white, foot-high letters: PLEASE OBEY THE HOLY SPIRIT.

Back when Nabb made his first Holly Run, the church elders met to debate the moral implications of decorating a church with greenery, a custom that Nabb suspects may have struck some as vaguely pagan. Evidently any objections were quashed—a welcoming committee was formed, and the islanders came to look forward to the arrival of the holly-bearing fleet. Still, an occasional rift has developed in one of the town's churches (as Nabb puts it, "If Mrs. A wants it, Mrs. B doesn't") and has spilled over into other congregation affairs; once or twice the pilots arrived at church only to find it closed. Nabb is sensitive to the town's ways: to avoid the appearance of partiality, he is careful to bring enough holly for both of Tangier's churches, the Methodist and the New Testament, the latter an emotionally charged congregation that evolved from a group that splintered off from the Methodists some 40 years ago.

It's not hard to understand the need for spiritual support here. This year a disease has decimated the oyster beds, and every week the oystermen have had to travel 65 miles down to the beds off

Newport News to make their living. And there's a greater, more insidious threat challenging the perseverance of the islanders: the water that provides the island its livelihood also threatens its survival. Assistant organist Dewey Crockett tells us that last year, 35 feet of beach eroded from winter storms. Most of the beach where the British set out to attack Baltimore's Fort McHenry in the War of 1812 has disappeared, and several hundred feet of the airstrip are now unusable.

Only a seawall, scheduled for construction starting in early 1989, will save the airstrip, and eventually the island, from extinction. Without the airstrip, communication with the mainland would be severely limited, perhaps in the winter to the single daily run of the mailboat to Crisfield, Maryland. The federal government, which built the runway as an emergency strip for airplanes operating out of the Patuxent River Naval Air Test Center, is contributing two-thirds of the overall cost of the wall. The rest is to come from the state and county—and the residents of Tangier, who face steep increases in property taxes.

After the service, Crockett's wife Jean helps coordinate the coffee and cookies in the building adjacent to the church. She's the island nurse as well as the high school English teacher. During the festivities she manages to direct plates of cookies to the pilots, warm up some milk for a fussy baby, and carry on conversations with several of us. Ginny Marshall, who has been coordinating the welcoming effort since the Holly Run began, also keeps busy, handing out coffee and chatting with the pilots. She's surprised about the large number of berries on the holly this year—"Bodes a cold winter," she says.

Several of us look around for Nabb, but he is nowhere to be found. Shortly after, we learn that an islander had suffered a heart attack earlier in the day and was taken by helicopter to a mainland hospital. There was no room for his wife, and the daily mailboat had already left. When Nabb heard about her predicament he left the celebration and took her to join her husband. That's the quality the pilots of the Holly Run all share: the willingness to extend a hand across barriers.

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Paris in Winter February 7-18: Experience art, theater, commerce, cuisine and more, in the quiet of the off-season.

Jamaica February 26-March 8: Study the customs and culture of this delightful West Indian island.

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Twelve Miles Over Laredo

How a Swedish pilot and a British balloon team set a world record high above a Texas border town.

by Nancy Shute

Photographs by Otis Imboden

Coy Foster was attending a consumer electronics show in Chicago when he got the word. Phyllis Kaupp was at a beauty parlor in Dallas. I had just returned from a gym in Washington, D.C., still sweaty. The message waiting for all of us was the same: The launch is a go. Come to Laredo ASAP.

Surely this is not standard operating procedure for a world-class aeronautical event, I thought as I drove through the mesquite-covered plains south of San Antonio at midnight with little more than notebooks, jeans, and sneakers. But in the rarefied precincts of high-altitude ballooning you must be prepared to seize the moment. The elements may not smile upon you again.

Manning the tethers

We had been summoned to a cattle ranch north of the Texas border town of Laredo to witness Per Lindstrand's attempt to top the existing hot-air balloon record of 55,134 feet, set by Julian Nott over Colorado in 1980. Such altitudes are beyond the reach of most hot-air balloons, which burn propane to heat the air in their envelopes. At great heights the oxygen is too thin to support combustion and breathing is impossible. And because blood literally boils in the upper reaches of the stratosphere, any aviator aspiring to that level must be well protected from the elements if he expects to return in roughly the same condition in which he left. Clearly this would be no Sunday jaunt in a wicker basket.

These are the sort of technological conundrums Lindstrand relishes. A 39-year-old native of Sweden, Lindstrand became a balloonist while in the Swedish Air Force. The hobby grew into an obsession, then a profession, finally leading him to England, where he founded the Thunder & Colt balloon manufacturing company in 1978. In July 1987 Lindstrand and British businessman Richard Branson became the first to cross the Atlantic Ocean in a hot-air balloon, a voyage that ended abruptly when their *Virgin Atlantic Flyer* plunged into the Irish Sea after touching down briefly in Northern Ireland.

Pilot Per Lindstrand

Lindstrand had scarcely dried off before he began gunning for the altitude record. He recruited the British firm ICI Films to sponsor the project, which was called Stratoquest, and produce a fabric that was even lighter and more durable than what the company had created for the *Flyer.* The result was a balloonist's dream: its 100-foot-tall envelope of ripstop nylon was eight times the size of a recreational balloon. Coated with an aluminized polyester film to retain heat, it could lift six tons but weighed only 500 pounds.

Lindstrand recycled an aluminum test capsule from the Atlantic effort. The five-foot pressurized sphere, coated with insulating foam, looked more like a giant marshmallow than an aircraft but contained all that was needed for the assault on the record: a padded seat, an altimeter and rate-of-climb indicator, temperature gauges for the fuel and the top of the envelope, controls for fuel pressurization and flow, two VHF communications radios, and a transponder to report position and altitude to Air Traffic Control. A tiny bubble on the top of the marshmallow and a window in the hatch would allow Lindstrand a limited view. And amid all the high-blown equipment, a Swiss army knife dangled from a clip at the pilot's eye level.

The capsule was crowned with a two-stage burner made of titanium

One room, with view

June, moon, balloon

and stainless steel. Lindstrand planned to rise to 35,000 feet on propane and then switch to a secret mixture of propane, additives, and oxidizers for the rest of the climb. (High-altitude balloonists, like Kentucky Fried Chicken, never give out recipes.) All in all, the craft resembled a recreational balloon as much as a 757 does a hang glider.

Lindstrand hired Bob Rice, a meteorologist at the Weather Services Corporation in Bedford, Massachusetts, to determine the optimal location and timing for the launch. Rice, a maven of balloon meteorology, has counseled major hot-air and gas balloon endeavors as well as sailboat races and polar expeditions for 12 years. For the launch site Rice chose south Texas, with its vast plains. He homed in on the grim border town of Laredo for its proximity to the equator, where stratospheric temperatures of about minus 70 degrees would allow the balloon to operate at peak efficiency. The area's surface weather patterns are fairly settled in the late spring, and the prevailing westerlies would deposit the craft in the same country from which it departed.

June 1 was picked for the launch date, and during the last week of May Lindstrand and a half-dozen employees packed the craft into big wooden crates and left the green meadows of Shropshire for the brush country of Texas.

Laredo rancher Joe Finley, who owns the Callaghan cattle ranch in Encilan, 27 miles north of Laredo, offered a grass airstrip just off Interstate 35 as a launch site. Peter Mason, a London newspaperman-turned-balloon-event-organizer, set up a recreational vehicle at the ranch as a command center and began assembling cars, trucks, spotlights, generators, telephones, chase helicopters, and pilots. Lindstrand put the word out to Coy Foster, a Dallas plastic surgeon who holds his own list of ballooning records; to Doc and Joan Wiley, Albuquerque balloonists who had worked with *Double Eagle* pilot Maxie Anderson on his Atlantic crossings and had run the command center for the *Flyer*; and to Rory Calhoun, a London stockbroker who had set records for parachuting and hang gliding from a balloon piloted by Lindstrand. Together with Lindstrand's staff, they formed a formidable cadre of international ballooning all-stars—much to the consternation of the U.S. Border Patrol, which hadn't anticipated so many foreigners passing through its checkpoint between Laredo and the ranch at all hours.

Inflationary tactics

By Memorial Day, all was ready. All, that is, except the weather. The usually limpid Laredo skies darkened as a series of fronts swept in, scouring the brush with 40-mph winds. The launch was postponed to June 2, then June 3, then June 4. Still no go. The forecast for Sunday, June 5, looked promising. But on Friday morning Lindstrand spoke again with Rice in Bedford and they agreed that the still-gusty winds made the prospect of landing among the 10-foot-high mesquite and cactus far too likely. The dispirited team members headed off once again across the Rio Grande for the dubious consolations of the Nuevo Laredo bars.

Just after noon Saturday, Lindstrand and Rice conferred again. The storm system had moved east; the wind had died. Launch was set for 6 a.m. Sunday, when surface winds would be at their calmest. The calls went out.

When I arrived at the Callaghan Ranch at 3:30 a.m. the field was ablaze in light, the uninflated balloon a silver pool in the parched grass. A half-dozen figures in white Thunder & Colt coveralls hovered around the capsule. Coy Foster's volunteers, including real estate agent Phyllis Kaupp, showed up wearing yellow "Arriba-Hooey Balloon Team" T-shirts. They had come down from Dallas to head up the recovery team.

A half moon hung overhead as the crew and volunteers cautiously unfolded the delicate envelope. At the perimeter of

Soaring but still sandbagged

the circle of light, I stood with three dozen other observers, hardly the horde of ravenous Fleet Street newshounds that had descended on the *Flyer* launch. Two Swedish documentary filmmakers scurried about with a tangle of microphones, wires, tape decks, and cameras. A pair of poker-faced Border Patrol agents lounged against a pickup truck. Edith Grinnan, Joe Finley's 93-year-old mother-in-law, hobbled out from the house and settled into a lawn chair, tended by her granddaughters. Bronco, the Finleys' sheepdog, wandered about, stopping for pats on the head. A local TV reporter stood with her notebook ready and her carefully painted eyelids at half-mast. Two men from Laredo strutted past in cowboy boots and tight jeans. Except for the darkness and the silver pool at our feet, we could as easily have been waiting for the Laredo Fourth of July parade.

Meanwhile, back at the ranch

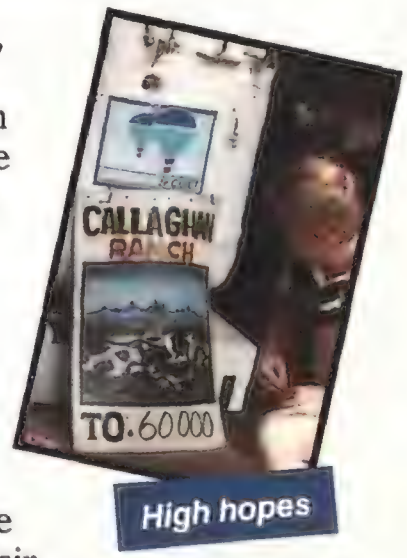
At 5 a.m. launch director Paul Dickinson gathered his people and the volunteers into a huddle and assigned launch positions from a detailed two-page plan. "That's it, really," he said quietly. "If you could all take your positions now."

The crew wheeled two waist-high fans to the mouth of the envelope. It bellied out, quickly assuming its rightful shape while lying on its side and tethered at top and base. At 5:30 Dickinson stepped into the gaping mouth with a portable burner and fired a six-foot flame into the envelope. Minutes later the balloon rose slightly, still tethered. I walked to the left to get a better view and felt a sharp *thwack* against my calf—Grandma Grinnan, armed with a cane. I stepped aside and took care not to stand in her line of sight again.

As Dickinson and Foster goosed the balloon with short bursts of flame, it strained against the slender cables that supported the capsule. The crew hung on the capsule as the balloon undulated in the 6-mph breeze, which was barely enough to tickle my cheek. "We've got a bit of wind," Peter Mason said with a note of worry as he eyed the silver globe crinkling overhead. "It puts tremendous strain on the flying wires. The balloon would fly now but it's not properly pressurized." He ran over to the Border Patrol officers and asked them to pitch in. Their faces broke into grins as they threw their weight onto the tethers.

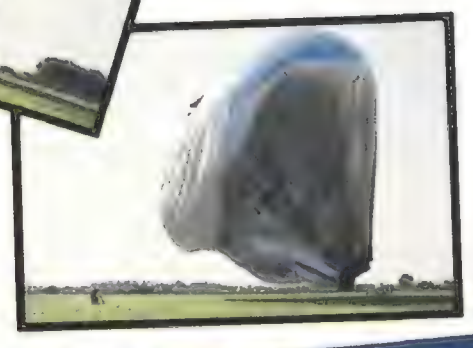
Even with 20 people holding on, the balloon still heaved. Dickinson conferred with Lindstrand, who was sitting in a Jeep breathing 100 percent oxygen to prevent the bends—nitrogen bubbles that could form in the blood at altitude. He leaned from the window and stared at the balloon, then stepped out and shucked off his helmet, revealing a drawn face. "We're calling an abort," he said. "We're not flying. There's too much wind." He shrugged and smiled. "Balloon flying is a waiting game. Everything is pointing toward improvement so we'll have a go tomorrow again."

The crew deflated the balloon and packed it in its box. I turned back for Laredo and bed, having just discovered a major liability of covering balloon launches.



High hopes

Monday morning, June 6, 4 a.m., same place, same players. The crew had taken the precaution of anchoring the capsule with three tethers, but this time there wasn't a trace of wind and the balloon rose unflinchingly, shining blue in the moonlight. At 5:21 Foster and Lindstrand drove up in the Jeep, and at precisely that moment, as if the gods were indulging a perverse sense of humor, the balloon began to crinkle ominously. "We're getting a bit of air movement," Mason said into his walkie-talkie. The capsule



Touchdown: the Texas two-step

The morning after

rocked, and the crew, the Border Patrol, and locals who had managed to make it out to the ranch a second night all jumped on the tethers. A *Houston Chronicle* reporter, whose shape roughly resembled that of the capsule, had changed his name badge to read "ballast."

Coy Foster helped Lindstrand wedge his 6-foot-2-inch frame into the bobbing capsule. The burners roared. "Clear the area downwind!" Dickinson shouted. "Keep your weight on!" At 5:42 the capsule suddenly left the ground, carrying a half-dozen crew members with it. They strained without success to detach two remaining 100-pound ballast bags, then dropped away. The balloon soared off into the black sky.

Grandma Grinnan folded her lawn chair and headed for the house, but the show had just begun. If Lindstrand could not cut loose the ballast bags, the record would elude him. At 6:09 and 20,000 feet, he managed to get rid of one of the bags. The crew stared at the pinpoint of light overhead, straining to hear a warning *whoosh*. I calculated the odds of avoiding a sandbag plummeting toward my head—another unanticipated balloon launch hazard. "I can hear it, I can hear it!" shouted Rory Calhoun. The bag landed with a gut-jarring thump about half a mile away.

By the time Lindstrand released the second sandbag, the balloon was well to the east and the mood was merrier. "Look at her glow," said Foster. "Oh, that's beautiful."

An hour into the flight, Lindstrand had ascended to 35,000 feet and had dropped two empty fuel tanks. The Houston Air Route Traffic Control Center picked up the balloon on radar. As the sun and the balloon rose, three chase helicopters took off and set down about 20 miles downwind with Foster, Dickinson, and Lindstrand's wife Helen. "I'm real calm, for me," she said with a laugh. "I'm used to these projects."

At 7:05 the radios crackled: Lindstrand had broken 57,000 feet, and the record. The crew cheered. "He got 60,000!" someone shouted few minutes later. But there was still much work to be done. As Lindstrand began to descend, the crew clustered around road maps, plotting a route to a landing site 60 miles to the east, then piled into two cars and a truck and drove off. The rest of us waited in the warming sun, gathering scraps of news from hand-held VHF radios.

At 12,000 feet Lindstrand relit the burners to control the rest of the descent. At 9:16 the capsule landed in a grassy field and was dragged barely 50 feet—a textbook landing. The crew was waiting with champagne.

Ninety minutes later Lindstrand's helicopter touched down at the ranch to a hero's welcome from the press, the jubilant colleagues, the radiant wife. However, this was a Texas welcome, staged among bales of hay and a lectern improvised of milk crates. "I'm sure I should tell you it was all skill, but it was all luck," Lindstrand said, gulping champagne with one arm around Helen.

Luck may have played a part, but skill and nerve carried him to what the sealed barograph later showed to be precisely 64,997 feet. But how had he gotten rid of those two bulky sandbags? The first was easy; it hung right outside the hatch, Lindstrand told us. But the line holding the second hung diagonally across the capsule. Lindstrand decided the only way to get rid of the bag was to disconnect himself from the oxygen system, climb out the door and across the capsule, and cut the bag loose. At 22,000 feet he figured he'd have several minutes before passing out. He clenched a Swiss army knife in his teeth and opened the capsule. "I just ran out," he said. "No, that isn't exactly the word. I monkeyed out: white knuckle to white knuckle to white knuckle." The little gathering grinned, delighted with this virtuoso display of Swedish *sangfroid* clothed in British moxie. "The only thing you need to fly a balloon," Lindstrand said with a wide grin, "is a Swiss army knife." ✈

The Mouse on the Moon

In Leonard Wibberly's 1955 novel The Mouse That Roared, *the penniless but resourceful Duchy of Grand Fenwick declares war on the United States in the hope of being instantaneously defeated and receiving an equally speedy infusion of rehabilitation money. However, the plan goes awry when Grand Fenwick*

ILLUSTRATIONS BY MICHAEL DAVID BROWN

inadvertently gains possession of the dreaded Q-bomb and wins the war.

"The world's smallest sovereign nation" then establishes the League of Little Nations, which enforces worldwide atomic weapons inspections and brings about "an uneasy peace between East and West." Yet Grand Fenwick remains penniless.

In the sequel The Mouse on the Moon, *Grand Fenwick's Count of Mountjoy comes up with another imaginative plan to improve cash flow and notifies the United States of an opportunity to make a tremendous contribution to world peace through the space race.*

Seated in his office in Washington, D.C., the United States Secretary of State scowled at the flurries of rain and sleet that slashed against the windows opposite his desk, seeing in them a reflection of the furies at work in the world of international affairs—furies which his best efforts had failed to abate after three years in office.

He envied his predecessors of a few decades back who had, for all the troubles of their times, lived in a world with a set and established number of nations, whose histories, economic needs and political ambitions were well known to them.

How different matters were now! New nations were popping into being as fast as mushrooms under a full moon. Twenty independent nations had come into existence in Africa in one year alone—some of them the equal of, or even bigger than, some of the oldest nations in Europe. . . .

Diplomacy in dealing with such countries had been reduced to a guessing game . . . . There was no other way to account for the colossal blunderings of all nations throughout their histories, in their dealings with each other. You got together all the information you could, and then you made a guess. Brilliant diplomats were actually men with a talent for guessing right and the same was true of brilliant generals and brilliant presidents.

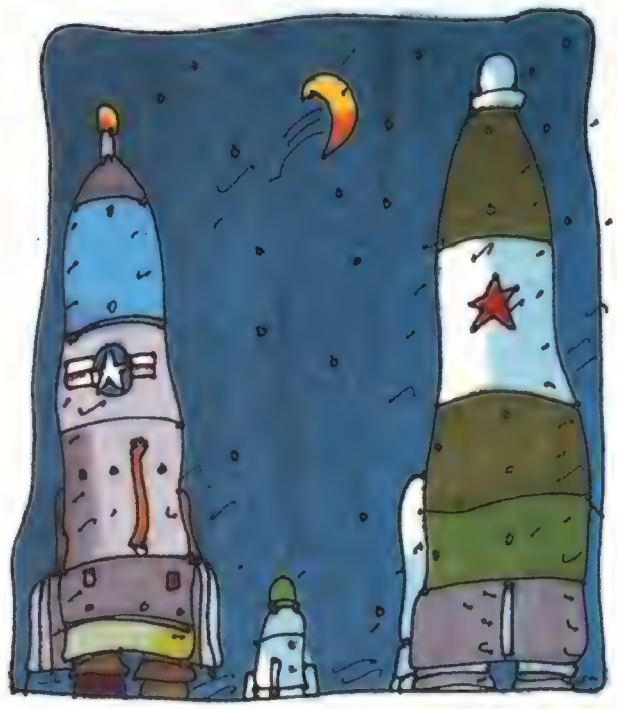
To reduce the hazards of this guessing game, the Secretary of State insisted that all communications addressed to him from foreign governments should be brought to his attention only when accompanied by a full summary of all the pertinent facts. This summary of pertinent facts, obtained from the heads of particular "desks" in his department, was always forwarded to the Secretary of State in a Red Folder—the color of the folder indicating immediately that the information was complete.

As many as a dozen of these Red Folders were placed on the Secretary's desk during the course of a normal day. There was a pile of them before him now and after contemplating the gloomy condition of both the weather and international affairs, the secretary picked up the first of them.

On it was a label reading "Duchy of Grand Fenwick." The Secretary frowned, experiencing a little tremor of anxiety, well aware of the trouble the United States had experienced with this little nation in the past. He felt indeed like putting the Grand Fenwick folder aside and turning to the next, which was marked "West Germany" and which, despite the still unresolved Berlin question, might prove less explosive. But the Secretary was Vermont-born and his boyhood training, which had insisted that he never turn aside from anything which was difficult or unpleasant, got the better of him. He braced himself and opened the Grand Fenwick Red Folder, and started reading the topmost paper in it . . . .

The Secretary of State
Government of the
United States of America
Washington, D.C.

Greetings:
I have the honor to inform you that at a meeting of the full representation of the Council of Freemen of the Duchy of Grand



Fenwick, held on March the fifth, the undersigned, as Her Grace's Principal Minister of State, was authorized to apply to the Government of the United States of America for a loan-in-aid, the precise wording of the enabling resolution being: "A loan of funds sufficient to ensure the continuing prestige of Her Grace and of her people."
The amount sought to achieve this estimable purpose, which I am sure will be heartily supported by the Government of

the United States (whose welfare we in the Duchy of Grand Fenwick have always close to our hearts) is $5,050,000. Of this sum $5,000,000 is required to finance a project to send a manned rocket to the moon and $50,000 is to be applied to the purchase of a fur coat for Her Grace the Duchess to surprise her on her birthday . . . .

"What the devil!" cried the Secretary of State aloud to his empty room when he had read this. "Five million dollars to go to the moon and fifty thousand for a fur coat. I've never heard of anything more nonsensical in my life."

He flung the Red Folder down on the desk in front of him, flipped a switch on the interoffice telephone and snarled into it, "Wendover, have the goodness to come to my office this moment . . . ."

Frederick Paxton Wendover was known among his colleagues on the second level of the State Department hierarchy as a man to watch. They agreed that while he was hardly likely to ever become Secretary of State, being incapable of making a public utterance or of creating any warm personal impression on others, he was one of those whose knowledge and insight into foreign affairs, particularly Central European affairs, would provide sure guidance for many Secretaries less brilliant than himself . . . .

Even the sight of Wendover standing before him helped to quell the wrath of the Secretary of State and restored some order to his outraged mind. He beckoned him to a chair and stabbing with a finger in the direction of the offending Red Folder said, "I suppose this isn't some joke of yours?"

It was typical of Wendover that he did not reply immediately, but instead picked up the Red Folder, opened it, glanced at the letter from the Count of Mountjoy and then said, "No, sir."

"Well, what the devil is the meaning of it then?" demanded the Secretary. "I can't believe what I read. Five million dollars for a rocket and fifty thousand dollars for a fur coat? What in hell am I to make of *that?* Are *they* pulling some kind of a joke?"

"Oh no, sir," said Wendover. "Mountjoy is in earnest, I am quite sure. You didn't read the full communication? . . . "

There was a suggestion of a rebuke in the question.

"No," snapped the Secretary. "I did not."

"I think it would be better if you read it through, sir," said Wendover, and the Secretary picked up the Red Folder again and with a scowl at Wendover continued with his reading.

In your approach to the Congress for the funds required [the letter continued], *you will naturally require to know for what reason the Duchy of Grand Fenwick wishes to send a manned rocket to the moon.*

In several recent statements, your own President has supplied the main ground for this project, urging the internationalization of the exploration of space, and stressing that it would be disastrous if the quarrels of nations on earth should be extended to proprietorship of the moon. Commendable efforts have been made by the United States, working through the United Nations, to secure agreement for international control of the moon—but without effect. It is plain that the old law of discovery, granting prior rights to the first to land, is likely to hold sway in space.

In these circumstances, Her Grace's government deems it a grave charge upon Grand Fenwick to intervene and send a manned rocket to the moon at this point, so that a third power representing nations other than the Big Two, is involved in the matter. This would have the effect of truly internationalizing the conquest of the moon as is the expressed desire of your President, and we are sure that the Congress will wish to implement the desire of the President by voting the necessary funds.

The fur coat . . .

But the Secretary didn't want to read about the fur coat and putting the folder down, looked dazedly at Wendover.

"They can't be serious," he said.

"They are serious," said Wendover calmly. "That is to say, Mountjoy is serious, though I suspect that this is all a plan of his own, and that he is applying for something for which he has not got specific authorization. He is a wildly imaginative and ambitious man. He is a firm believer in personal connivance as an instrument of government."

"That's outrageous," said the Secretary of State.

"It was the method of Disraeli in procuring the Suez Canal and of President Jefferson in obtaining the Louisiana Purchase," said Wendover quietly. "In neither case was the legislature consulted until the object was accomplished. Mountjoy fancies he comes from the same mold—and he may be right."

"But even supposing he obtained this money," said the Secretary, "and I'm not for a moment conceding that he will, what chance does a tiny state like Grand Fenwick, lacking any technological development at all—a state that is utterly and completely agricultural—have of developing a rocket capable of going to the moon when we ourselves have failed time and again?"

"Mountjoy is a statesman of the European mold," said Wendover, "which means that his stated objective in putting forward a plan is not necessarily the main one, nor is it necessarily one which he really intends to implement."

"Put that in plain terms," said the Secretary of State testily . . . .

"Mountjoy has been frustrated many times in the past in attempts to put into effect many programs he has had for the development of the Duchy," said Wendover. "These programs have included modernizing the highway system in the Duchy, putting up a tourist hotel of some distinction, revamping the plumbing in the houses of the people. Getting a hot bath in Grand Fenwick, sir, is still a three-hour project involving heating water in pots over an open fire. In all these projects he has been defeated by the Opposition, led by Mr. David Bentner who is the leader of what we will call the party of the people—not communist. Definitely anti-communist. But opposed to modern innovations that call for an increase in taxes.

"Now with regard to this application for a loan of five million dollars to send a rocket to the moon, I would say that Mountjoy's real objective is to get funds (without an increase in domestic taxes) to revamp the whole plumbing arrangement in the castle of Grand Fenwick and also get a start on his highway program and his tourist hotel."

"Then why doesn't he apply for this kind of assistance which we are usually willing to give to backward nations?" interrupted the Secretary of State.

"You unwittingly hit on the reason when

you spoke about 'backward nations,' sir," said Wendover. "No country likes to think of itself as a backward nation, particularly a country as proud of its history as Grand Fenwick. If Mountjoy applied directly to the United States for a loan to improve the—er—facilities in Grand Fenwick, he would bring down the wrath of the whole nation on his ears, for he would be making a national admission that his country was backward.

"He therefore hit upon this rocket pretext which lets him out and serves our purposes as well—as he explains in his letter."

"I don't agree that it serves our purposes at all," said the Secretary. "I don't agree with that in the slightest."

"I speak subject to your own more intimate knowledge of the whole situation, sir," said Wendover. "I don't pretend to be able to discuss the world picture with any degree of authority."

"Go ahead," said the Secretary. "Say what you have in mind."

"Well, as Mountjoy points out, it is part of the basic policy of this country to obtain, through the United Nations, international control of the moon, so that the quarrels of the earth are not extended to the moon, and the moon does not become a second Berlin, divided between East and West.

"However, if an agreement were achieved with the Russians on international control of the moon, it would really be bi-national control of the moon. It would be basically an agreement between the two nations—the United States and Russia, each with its own point of view, and these points of view are likely to come into conflict at any moment. We might call it international control, but it wouldn't be. It would be basically another Berlin situation—East versus West.

"We, on our part, want to avoid that. We can't avoid it unless there is at least one other party involved. That would give it some kind of international flavor. If we could go before the United Nations and say that in our desire that the moon should be internationalized, we had advanced funds for research in getting a manned rocket to the moon to another nation outside our sphere of influence and with which we have no close connection, then we would have demonstrated our sincerity in attempting to get international lunar control. Mountjoy suggests this path though, as I have said, his real objective is probably to get a hot bath for himself and some decent roads in Grand Fenwick. But it is a path—an approach—which is very useful to us. It serves our purpose. And it serves it without detracting in the slightest from our national achievement if and when we get to the moon, or our national bargaining position."

"But Grand Fenwick?" said the Secretary of State. "Nobody is ever going to believe that we are serious in offering Grand Fenwick money to get to the moon. Grand Fenwick hasn't got a chance."

"They wouldn't believe it if we offered the money to any other small country," said Wendover. "But Grand Fenwick—Grand Fenwick is different."

"Why?" demanded the Secretary.

"Because of Dr. Kokintz," said Wendover. "He is the world's outstanding physicist and he lives in Grand Fenwick. There is just enough in that for people to suspect that he may be engaged in some kind of research regarding—well, rocket fuels. The man who invented the quadium bomb commands world respect. There is enough world respect for Dr. Kokintz for people to think—even Russia—that our offer to Grand Fenwick is sincere. And it would be sincere. It is a gesture only, of course. But it is a sincere gesture, costing only five million dollars which will do much to convince the world of our ardent desire to obtain a true international control of the moon—and of outer space when that field is opened up."

"And the fur coat?" asked the Secretary.

"That is undoubtedly a genuine objective of Mountjoy's," said Wendover. "But we have again to look for an ulterior motive, Mountjoy being, as I have stated, a statesman of the European kind. His ulterior motive, I would guess, is that with the presentation of the fur coat, which is tied in with the whole loan, he may be able to mitigate a great deal of hostility which may develop when what he has done is discovered, because of the people's deep affection for the Duchess. As I said at the beginning, sir, I believe that Mountjoy has far exceeded his authority in applying for this sum. But if he gets what he asks for, and people start getting plenty of hot water in their homes and a good road through the Duchy and decent sanitation, and the Duchess gets a fur coat, then most of that hositility will disappear and he may well become for a while a national hero."

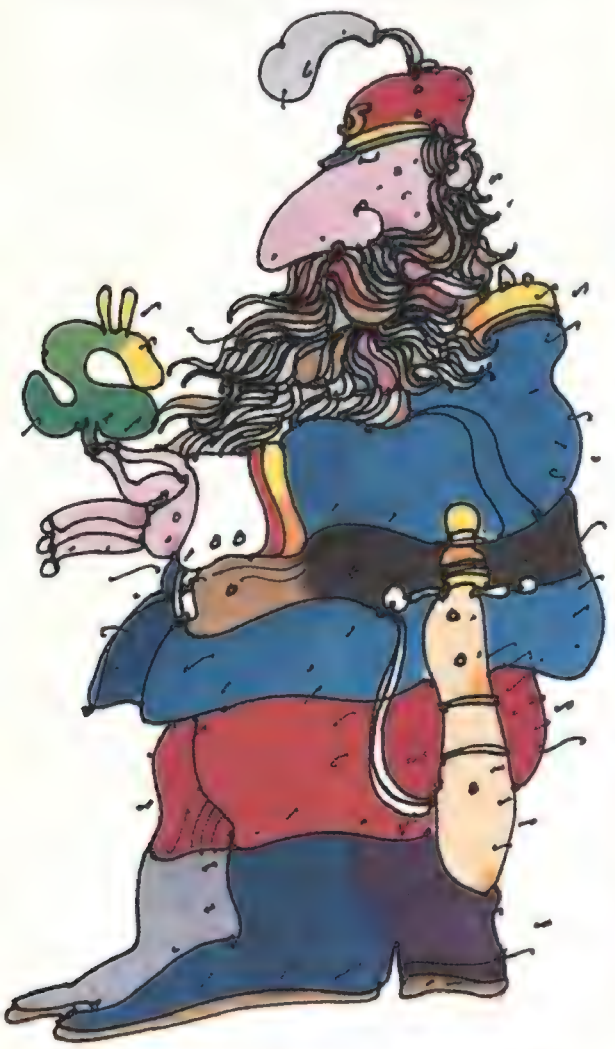
"You think we should grant this request for funds then?" asked the Secretary of State.

"Oh yes, sir," said Wendover. "Mountjoy is actually doing us a service. He makes it possible for us, with the expenditure of only five million dollars, to put the Russians in a position where they can hardly refuse true international exploration and control of space. That's not as much as one of our big rockets costs, I think, sir."

The Secretary was silent for a while, marveling at the mental subtleties of the Count of Mountjoy . . . .

Aloud, he said to Wendover, "Give me a memorandum on this subject and I'll take it up with the President. You can recommend an outright grant. It would look better when we report to the United Nations if we say it was a gift with no strings attached. In any case, we have no hope of getting it back again. But five million dollars is ridiculous. It is too small. It would lack conviction when we go before the United Nations with the announcement. Better make it fifty million dollars. That would make it sound like a more genuine offer for funds for lunar research."

"Fifty million!" exclaimed Wendover.



"But, sir, whatever would they do with the surplus?"

"That's their problem," said the Secretary, almost savagely. "They can rehouse everybody in Grand Fenwick for all I care, and buy them automobiles. They may want to start a university over there. Anyway, it's their problem, as I say. My problem is not to jeopardize the success of this whole effort by being niggardly. In any case, we give so much money to nations which are wavering between us and the communists, it will be a pleasure to make a substantial gift to a nation whose principles are unshakable and coincide entirely with our own."

From The Mouse on the Moon, *copyright 1962 by Leonard Wibberly. Reprinted by permission of McIntosh and Otis, Inc.*

The Gagarin Inquest

Truth is difficult to find in the charred debris of a crash. Pilots often question accident reports and sometimes even get them changed. With so much liability involved, vigilance is warranted to keep an investigation from protecting narrow interests. This is one reason I question the report issued by the Soviets this year about the accident that killed their hero Yuri Gagarin 20 years ago.

When Gagarin's MiG-15 went down in March 1968, seven years after he had become the first man to orbit Earth, an official inquiry was conducted, but the results were kept secret. In 1987, *Pravda* finally told part of the story, and last January it supplied what is supposed to be a full disclosure of the old inquiry and a new investigation. The *New York Times,* putting the two accounts together, reported last February 9 that one acknowledged purpose of bringing the story into the open was "to dispel rumors that have circulated over 20 years, ranging from tales of Colonel Gagarin's flying drunk to speculation that he had become too popular or had otherwise fallen from political favor and had been eliminated in a staged accident."

According to *Pravda,* Gagarin and another Soviet colonel, Vladimir S. Seregin, were headed for an airfield near Star City, the Soviet space training center northeast of Moscow. That early spring day, their MiG-15 two-seater was at 14,000 feet and between cloud decks, a situation that required them to fly mostly on instruments. They could probably see the horizon—and thus whether the airplane was right side up—but not the ground.

While Gagarin and Seregin were starting their approach, a MiG-21—"a much larger jet," as the *Times* put it—passed within 2,000 feet. "Turbulence of the MiG-21's powerful jet wash sent the MiG-15 into an almost vertical dive," the *Times* reports as *Pravda*'s explanation. The two pilots thought the controllers called out the altitude of the lower cloud deck at 3,500 feet. In fact, it bottomed out somewhere between 1,500 and 2,000 feet. Gagarin and Seregin, again according to *Pravda,* assumed they had enough ground clearance to recover in time from the dive below the clouds. Because of the misunderstanding over the heights, the aviators started to pull out two seconds too late and both were killed.

Nothing is impossible, of course. Stranger things than the events in the Soviet accounts have caused accidents. But

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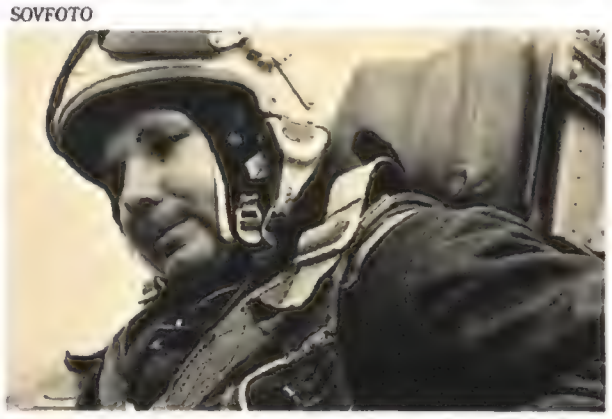

Yuri Gagarin was 34 years old when he died during a routine training flight.

in light of the admission of concern for Gagarin's reputation and the Soviet description of Gagarin's very heroic efforts to recover from the conditions in which he found himself, this reconstruction impresses me more as a public relations effort than as an accident report.

Pravda reported that jet wash sent Gagarin into a dive. My experience with wake turbulence has been in prop-driven fighters, not jets. But the fundamental effect is about the same: the airplane that flies into it wants to roll. Assuming wash is strong enough and pilot reaction slow enough, it is within the realm of the possible that the airplane could roll completely on its back, stall, and spin. However, flying wing in an F4U in the Navy, I slid close behind my leader often enough to know that a quick and firm hand with the opposite aileron will preserve level flight. Moreover, the turbulence tends to push the aircraft out of its path; that is, it actually aids in recovery.

A Navy test pilot and a former airline chief engineer to whom I related the Gagarin story both scoffed at these proposed consequences of a near collision with a MiG-21 as far as 2,000 feet away. Another pilot, who flies F-16s, described jet wash at that distance as a problem that can be coped with.

An article in *Soviet Life,* intended for an American rather than a Soviet audience, pulled back from the specific explanation of the MiG-21's powerful wash and offered several possible causes for the dive: avoidance of another aircraft, balloon, or even birds, or simply severe turbulence. These are plausible causes, sure, but it is hard to imagine a fighter unable to recover from such an unusual attitude at 14,000 feet, where *Soviet Life* says the dive started.

Assume that Gagarin's craft was in a dive—for whatever reason. Pilots don't like to postpone recovery. That goes triple for diving through clouds. I have seen pilots loop through low cloud decks at the Paris airshow, to much clucking on the part of witnesses on the ground. Any pilot knows cloud decks are erratic. Even if the clouds are stable, the terrain below may not be. Too many pilots have bored through clouds into sides of mountains that weren't supposed to be there.

Gagarin would have known all this. Soviet pilots, though, have a reputation for being heavy-handed at the controls and casual about niceties. And cosmonauts, at least then, were not virtuoso pilots but passengers under total ground control. Possibly, they were chosen for physical condition, not flying skill.

I admit that one of the reasons I question *Pravda*'s explanation for Gagarin's death is that reading it triggered a flashback: the nose of a Soviet Tu-144 supersonic transport falling through what looked like a hammerhead stall. That sight was followed by a grim sequence that ended when the airplane disintegrated in a cloud of vapor in a hazy, fair-weather cumulus sky one June afternoon.

It was the last Sunday of the Paris airshow, what seems an unbelievable 15 years ago. I was standing on the roof of a hospitality chalet near the flight line, next to Bob Hoover, one of the most precise demonstration pilots in the world. We had

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The national mourning of Gagarin was a sign of Soviet reverence for cosmonauts.

both cringed at the sloppy airmanship of the pilot flying the big but lightly loaded Tu-144. It had been modified that year with canards that retracted just below the cockpit for high-speed flight and extended for the low-and-slow. The airplane had staggered around its final turn to land at Le Bourget, a rather tight turn started from too close in to the runway. It seemed so close to stall I feared that airplane parts would be sprayed like shrapnel through the crowd.

Fortunately for a half-million spectators, the Tu-144 made it. The canards may have been enough to get the airplane around that hairy turn. At full throttle, afterburners bellowing and spitting flame, it climbed out at a showoff steep angle to prove it was as hot a rock as the British-French Concorde supersonic transport, which also had been stunning the crowds.

As the Tu-144 leveled off and began to fade in the distance, clearing the stage and getting ready for landing, Hoover and I relaxed and watched for his turn back toward Le Bourget. Abruptly, the nose dropped. Against the haze, the Tu-144's needle-nosed fuselage and delta wing were outlined like an engineering planform drawing of the airplane's underside.

Hoover banged the shoulder of a photographer next to me and shouted, "Quick! He's going in." The Tu-144 rolled to the left, showing a perfect side profile this time, and started to pull out of the dive. Then what looked like a piece of the wing snapped off. Vapor—probably fuel—spewed out and enveloped the airplane like smoke. It disintegrated in a fraction of a second. All aboard died, including a likeable young flight engineer who had given me a Tu-144 pin a few days before. The wreckage also killed citizens of the small village near Le Bourget where it fell.

Afterward, there were as many theories about what caused the crash as there were aviation experts watching on the ground. The report issued by the Soviet and French authorities, however, said that the Tu-144 pilot had been startled by a French jet fighter flying close overhead taking aerial photographs of the show. In reaction, the report said, the Tu-144 pilot jammed the nose down and then could not recover from the dive in time.

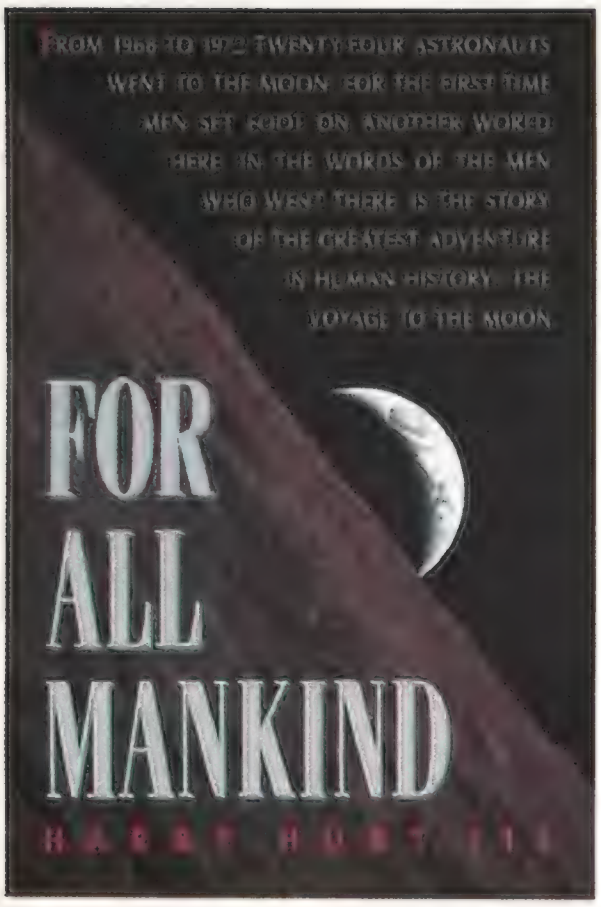
It is an odd coincidence that the sudden avoidance of another aircraft caused two of the most notorious crashes in Soviet aviation history. Personally, I could never swallow the Tu-144 story, not the least because I think I would have seen the French Mirage from the ground if it had flown close enough to require an avoidance maneuver. I talked with many experts who witnessed the Tu-144 crash, and none of them believed the official explanation. The French would have had good reason to whitewash the accident. Not only is the airshow a source of immense revenue, but the exhibition is the most prestigious in the world. Besides, the French undoubtedly wanted the Soviets, one of the show's brighter attractions, to return.

The explanations for the Tu-144 and the Gagarin accidents have a more damning characteristic in common: neither reflects upon the skill of the pilots or the performance of the airplanes. Both pilot and craft are depicted as victims of misfortune, of unhappy coincidences. The explanations require no investigation of the quality of Soviet products, which must compete in world aircraft markets. And the Gagarin report ignores the question of whether Gagarin got himself into an unusual attitude at low altitude by being cocky—the way I used to boot my old Navy Stearman N2S biplane trainer into a spin to lose altitude rather than take the slow way down, back when I had all of a hundred hours of flight time.

Naturally the *Times* did not accept at face value the new Soviet openness about aircraft accidents as it related to the Gagarin crash account. It did quote American experts who accepted the report, but they were space experts. Pilots and aeronautical engineers are likely to react more skeptically, as my friends and I did—especially those who noted that there was not even the vaguest hint of pilot error or equipment malfunction, both of which figure prominently in so many Western accident reports.

No one, here or there, wants to see reputations tarnished. But the Soviet report of the Gagarin accident is too vague and convenient to satisfy pilots in the rest of the world.

—William H. Gregory



***For All Mankind** by Harry Hurt III. Atlantic Monthly Press, 1988. 364 pp., color and b&w illustrations, $22.95 (hardbound).*

What was it like to go to the moon?

In an attempt to answer that question, Harry Hurt III has gone to the source: the 24 men who, between December 1968 and December 1972, either circled the moon, walked on it, or both. He has taken his material chiefly from a series of interviews made for a documentary film of the same name (for which this is a "literary sibling"), from the few books written by astronauts, and from transcripts of the Apollo mission commentaries, which were provided by NASA during each flight. It appears that he personally interviewed only two Apollo astronauts.

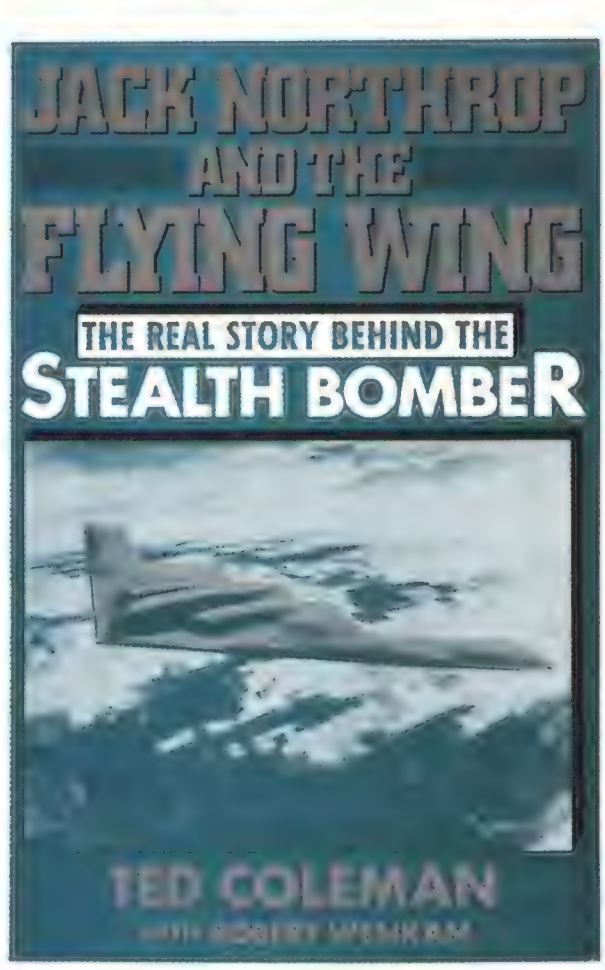
From these accounts, real-time and retrospective, Hurt has constructed a kind of composite Apollo mission. Devoting a chapter to each major phase of a lunar flight (pre-launch preparations, liftoff and ascent to Earth orbit, translunar insertion, and so on to re-entry and splashdown), he has collected impressions from different crewmen for each phase. The result is probably as good a description as we are likely to get of what it was like to go to the moon. Yet it is a strangely bland and uninspiring tale. Perhaps my reaction is conditioned by an excessive familiarity with the Apollo missions, but in any case I came away unsatisfied. Maybe you just had to be there.

This problem is not entirely the author's fault. Hurt is clearly enthralled by manned space flight, and he enlivens the story by stressing the inherent dangers of the missions and building up suspense at those points where things almost did go wrong. The failures of drama seem due mostly to the astronauts themselves. Hurt points out that these were by nature and training nonverbal men, and as the narrative makes clear, at just those points where we would most like to know what was going through their minds, they were too busy with critical tasks to register vivid impressions. This seems to be a pretty accurate picture of the Apollo missions; so much to do and so little time.

For All Mankind concludes with a chapter on the later careers of the Apollo astronauts, one attempting an assessment of the project's value, and one looking ahead to possible courses for space exploration (drawn largely from the post-*Challenger* report of a task force headed by former astronaut Sally Ride). Hurt firmly believes Apollo produced spinoffs of major economic importance, but he does not document this convincingly and he ignores economic studies that have consistently failed to demonstrate any widespread technological fallout directly attributable to the project.

I could recommend this book as a one-volume story of manned lunar exploration except for the abundance of factual errors. I counted nearly 100, from failure to check facts to serious misunderstandings of the technical aspects of Apollo. For example, Neil Armstrong did not climb out through the roof of the lunar module, as Hurt asserts; the egress hatch was in the front of the vehicle. Gemini 9-A did not make three dockings with its Agena target vehicle; docking proved impossible because an aerodynamic shield failed to separate from the Agena. And the lunar module did not use the same fuel as the Saturn V. Knowledgeable readers will feel cheated by this careless work, and those less familiar with the Apollo project will be left with many false impressions.

—Wm. David Compton is the author of a forthcoming history of the Apollo lunar exploration missions, a volume in the NASA history series.



***Jack Northrop and the Flying Wing: The Real Story Behind the Stealth Bomber** by Ted Coleman with Robert Wenkam. Paragon House, 1988. 284 pp., b&w photos, $24.95 (hardbound).*

Ted Coleman recalls that the Army Air Corps clamped a lid of secrecy on the Flying Wing during World War II, but you can't hide something so wondrous from a 12-

***The Home Planet**, conceived and edited by Kevin W. Kelly for the Association of Space Explorers, foreword by Jacques-Yves Cousteau. Addison-Wesley Publishing Company, 1988. 256 pp., color photos, $39.95 (hardbound).*

For those of us who can't join the Association of Space Explorers, whose prerequisite for membership is the experience of orbiting Earth (see "The Hundred-Mile-High Club," April/May 1988), *The Home Planet* will have to do. A collection of spectacular space imagery (such as this photograph of the Himalayas taken on a 1984 flight of *Challenger*) interspersed with quotes from the astronauts, this coffee-table book is a visual feast.

year-old. I learned about the Wing from an advertisement in *Life* magazine, in which the airplane's virtues were compared to those of Prince Albert pipe tobacco.

"Daddy!" asked the young woman in the ad. "What's happened to the rest of the plane? Did it break off?" *Just like a girl,* I thought in 1943, but as a skeptical grownup in the Jet Age, I saw her point. Why build an airplane without fuselage or tail?

Now here is Mr. Coleman, a former vice president and director of Northrop Aircraft Company, to again raise the question. If the United States had adopted the propeller-driven wing, he says, it could have had a 10,000-mile bomber as early as 1946. Furthermore, the airplane would have been *invisible to radar.* For what is the B-2 Stealth bomber if not an updated version of Jack Northrop's Flying Wing?

In making his case, Coleman also gives us a biography of Northrop, a history of his company, and his reasons for believing that a competitor grounded the Wing for nearly 40 years. To accept this last point, you must be prepared to accept that an airman twice sabotaged the jet-powered Wing; that the procurement contract was canceled because Northrop would not agree to merge with his rival, and that the U.S. Air Force then falsified the test results and cut the surviving aircraft "into pieces small enough to throw into dump trucks." It was, Coleman writes, "as if the Air Force wanted to . . . erase all memory of [the Wing's] existence."

A generation later, the United States is spending billions of dollars to resurrect the configuration Jack Northrop pioneered. Not only is Northrop the prime contractor, but the company is also building the B-2 in a super-secret hangar at Edwards Air Force Base, named for Glen Edwards, the Air Force captain who was killed while testing the possibly sabotaged Wing in 1948.

It is a grand yarn, but there are gaps in the argument (the saboteur is never identified, for example). As a result, I am not entirely convinced that these crimes were committed, or even that Stealth is the Wing reborn. Worse, despite his subtitle, Coleman has little to say about the B-2 itself—not enough, anyhow, to satisfy the 12-year-old who still lives in me.

—Daniel Ford wrote "One Hundred Hawks for China" in the April/May 1988 issue of Air & Space/Smithsonian.

***Press On! Further Adventures in the Good Life** by General Chuck Yeager and Charles Leerhsen. Bantam Books, 1988. 247 pp., b&w photos, $17.95 (hardbound).*

In *Press On!* Chuck Yeager tells us in detail how the entire Yeager clan, from Grandpa and mother Susie Mae to sister Pansy Lee and daughter Susie, has always been endowed with the Stuff Tom Wolfe was the first to observe in the General.

The Stuff is more than just flying, we learn in a collection of what seem to be unedited transcriptions of tapes made by Yeager, his wife Glennis, and his best pal Bud Anderson as they reminisced about Yeager's life. First, the family always keeps a stiff upper lip. "Being a Yeager, I was naturally skilled at controlling my emotions . . . ," Yeager says in a passing mention of the accidental shooting and killing of his little sister by his six-year-old brother. The result was intensive instruction in firearm safety by father Albert, "to make something constructive out of the loss, which he did."

Then there's the hiking and hunting, which Yeager says builds character. "Yeager means hunter in German," he tells us, and whether it's clubbing a halibut to "drag the sonovabitch into the boat" or steering a C-45 into a buzzard "to knock that thing out of the sky," Yeager goes for the gusto. "What Chuck Yeager *does* is fly and fight," the General explains. Nothing in the food chain—bear, elk, deer, coyote, rabbit, squirrel, duck, goose, quail, partridge, pheasant, turtle—is safe if there's an armed Yeager within 50 yards.

When Yeager pauses for breath, Anderson jumps in with paeans that open with "You never get bored hanging around with Chuck" or "One reason Yeager seems somehow larger than life to me . . . " or "Chuck is the best shot I've ever known."

The few bearable passages in *Press On!* are Glennis' recollections of early married life, particularly her first encounters with Yeager's hometown of Hamlin, West Virginia. She has trouble understanding "the heavy twang" and the "words and phrases that aren't in the English language" and why the locals "kept wallpapering their houses every few years . . . until the walls were so thick and bumpity that it looked ridiculous. Then they'd pull it off and start again." Even less appetizing was West Virginia cuisine—corn bread and biscuits drenched with hot pork grease, which was also applied to salads. "Life, Chuck, doesn't *have* to be this hard," she once told him while driving through Hamlin after the annual spring flooding of the Mud River.

But it does, if only to keep the General happy. "[C]*oping* with the bitch has to be what makes the experience satisfying," he says. That includes hiking without tents and sleeping among rattlesnakes and bears, as well as weeding out "the weak sisters" as an instructor with Anderson at desolate Perrin Field in Texas. Yeager crows that their fellow officers at Perrin were openly jealous. "We were the *real* Air Force," he declares, and when he flew the X-1, he did so "on the ragged edge, where I was naturally most comfortable."

But Glennis confides that Yeager is really a gentle cuss at heart. "His big thing with

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(signed) Diana L. Barclay
Business Manager

me is to tease" while she suffers from repeated bouts of ovarian cancer. " 'Well, when you're six feet under,' he'll say. Or, 'Don't you go kicking the bucket before you've got such and such done.' "

"In an era of so few role models with guts and integrity," the book jacket reads, "Chuck Yeager is truly an American hero." And a famous one to boot. But, to paraphrase Andy Warhol, everyone is famous for 15 minutes. Someone should tell the General his time is up.

—Patricia Trenner is the departments editor of Air & Space/Smithsonian.

***Orbital Mech** by Dale M. Greer. Studio Zero, 6212 Amuell Boulevard, Suite 153, Dallas, TX 75228. For Macintosh and Macintosh II computers (with 512K RAM). $49.95.*

You learn a lot playing Orbital Mech, but don't let that put you off. It's not "educational software" but a true game. To play, you maneuver your shuttle craft against the wild and crazy forces of gravity that disturb it. In the process, many of the physical laws that govern the way a spacecraft behaves in orbit will become intuitively obvious even if the mathematics in the manual takes a little longer to absorb. And hats off to Orbital Mech's designer: intuition and science get equal billing.

In its simplest form, the game involves a shuttle in orbit around a single gravitational body—a "unary" system. The shuttle can be maneuvered by rotating it or by firing thrusters aligned with its long and vertical axes. The controls are simple but take some time to get used to unless you accept the manual's advice to divide control between the computer's mouse and the keyboard.

After some practice, you'll be ready to try docking with a space station. Then you can add a second gravitational body, experiment with apsidal and intersection thrust maneuvers, try a Hohmann transfer or two, and even a spiral thrust maneuver—all basic moves used by the pros. After you increase the masses of the gravitational bodies and adjust their distance to magnify their influence on the shuttle and the space station, docking becomes a task that can be compared to bringing a supertanker alongside an anchored rowboat in a hurricane.

If you've ever wondered how spacecraft launched at different times and places match orbits and link up, a few hours with this game will help you understand.

—George C. Larson is the editor of Air & Space/Smithsonian.

Credits

April on Ice. Retired Air Force colonel Henry R. Johnston has 6,000 flying hours in more than 35 types of aircraft. His military flights include piloting P-38s over the south Atlantic to Africa and directing Berlin airlift missions.

Type Caste. Ann Hood has recently published a second novel, *Waiting to Vanish* (Bantam, 1988).

Holding the Line. To report his story, George C. Larson flew low and slow in an O-1 Bird Dog.

Baron Wolman was the first chief photographer for *Rolling Stone.* A specialist in aerial photography, he shoots the Superbowl every year for the National Football League.

The HOTOL Man. Tom Huntington is the managing editor at *Air & Space/ Smithsonian.*

Space Stations in Lobbyland. Eliot Marshall is a reporter for *Science* magazine in Washington, D.C.

Max and the Mini-Space Station. T.A. Heppenheimer is a frequent contributor to *Air & Space/Smithsonian.*

Masters of Soaring. Doug Stewart's last article, "High Society" (October/November 1988), reported on the L-5 Society, whose members want to colonize space.

On the Road to Io. A resident of Hawaii, Thelma Chang grew up within sight of the big island's Mauna Kea observatory.

Bringing Up Betsy. Frank Winter is an assistant curator of the National Air and Space Museum's space science and exploration department. A specialist in early rocket history and early science fiction, he is the author of *Prelude to the Space Age: The Rocket Societies, 1924–40* (Smithsonian Institution Press, 1983).

Holly Run. J. Forrister Ross is an editor at Smithsonian Books. His story is based on his participation in last year's Holly Run. December 17 is the date of this year's run.

Twelve Miles Over Laredo. Nancy Shute is a Washington, D.C.-based writer specializing in science and the environment.

The Gagarin Inquest. A retired naval aviator, William H. Gregory was the editor of *Aviation Week and Space Technology,* where he worked for 30 years.

"The Satellite Sky" Update/10

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

Deletions

90 to 300 MILES

Cosmos 1955 down 8-20-88	Cosmos 1962 down 8-22-88	Soyuz TM-5 down 9-7-88

Launched but not in orbit

90 to 300 MILES

Cosmos 1963 USSR photo recon	8-16-88	down 10-2-88
Cosmos 1964 USSR photo recon	8-23-88	down 9-7-88
Cosmos 1965 USSR earth sensors	8-23-88	down 9-22-88
Cosmos 1967 USSR photo recon	9-6-88	down 9-15-88
Cosmos 1968 USSR earth sensors	9-9-88	down 9-23-88
STS-26 USA research	9-29-88	down 10-3-88

Inoperative but still in orbit

90 to 300 MILES	6,200 to 13,700 MILES
Cosmos 1958	Cosmos 1884

300 to 630 MILES

Cosmos 1808

TAI denotes Taiyuan, a launch site in the Shanxi province of the People's Republic of China. NEG stands for Israel's Negev Desert, the location of a new launch site.

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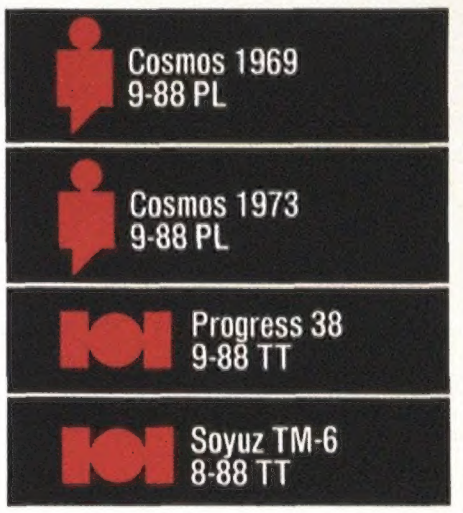
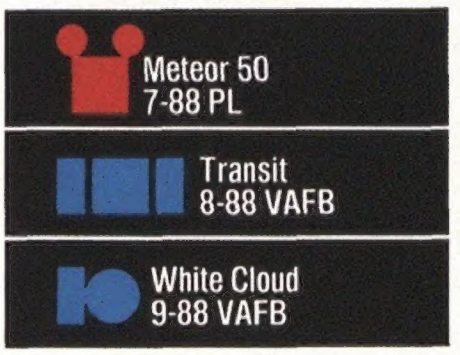
New launches

90 to 300 MILES



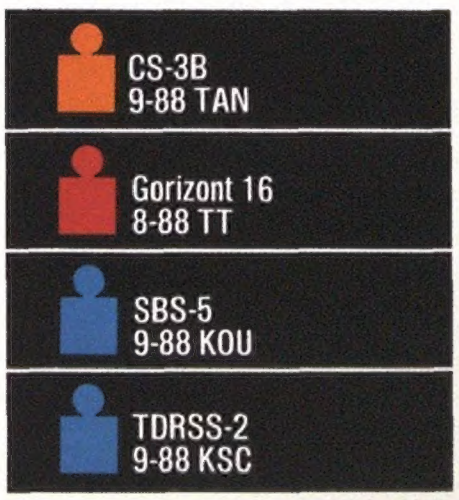
300 to 630 MILES

630 to 1,250 MILES



6,200 to 13,700 MILES

21,750 to 22,370 MILES



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Forecast

In the Wings . . .

ALAN G. AMPOLSK

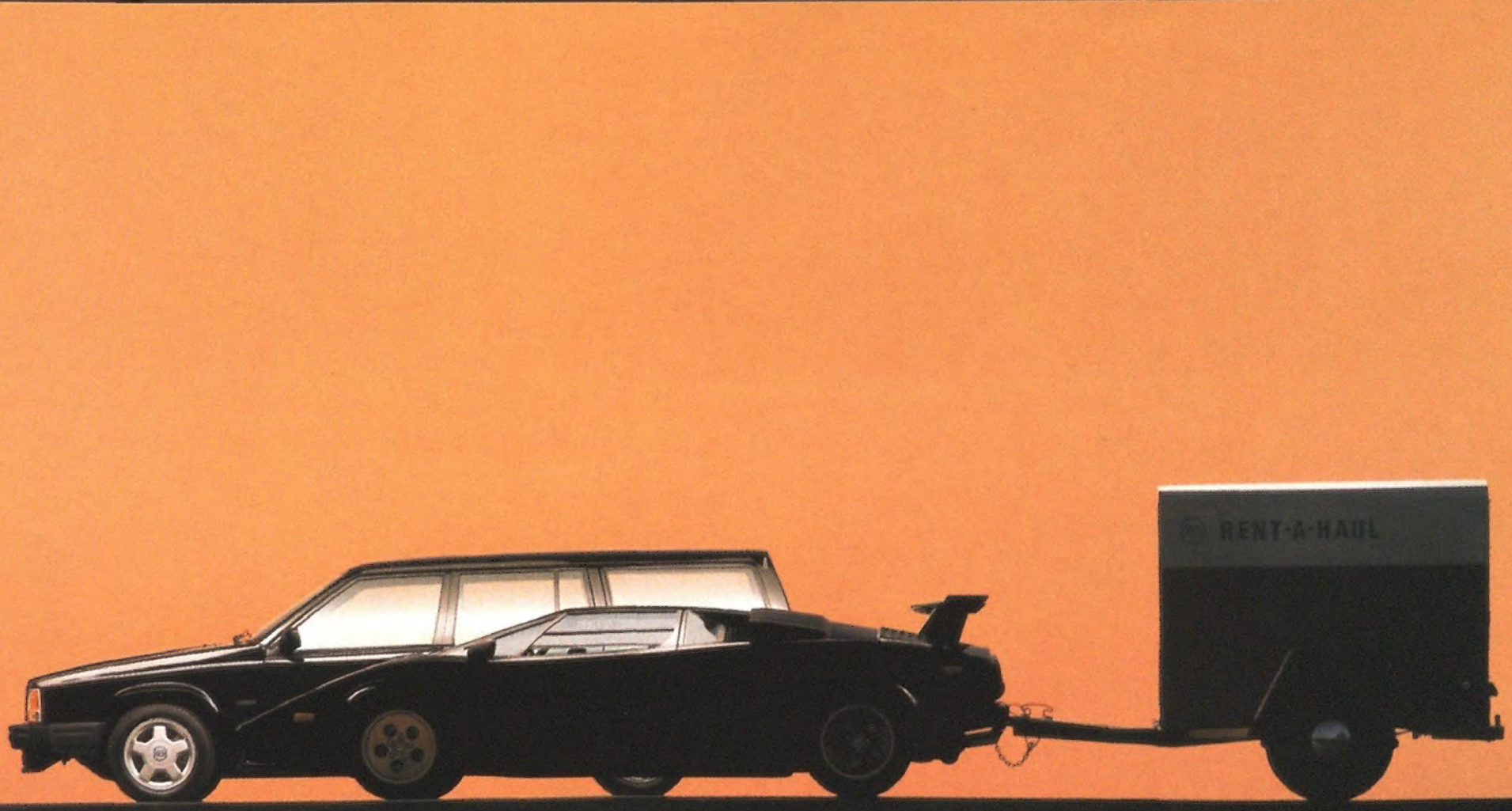
Lost Luggage—In the airline industry, the people wearing grim expressions and heading for Lost and Found are called PAWOBs—Passengers Arriving Without Bags. In addition to their bags, the PAWOBs are looking for the SSOBWLMLs—the Stupid S.O.B. Who Lost My Luggage. Passengers blame baggage handlers, handlers blame skycaps and reservation agents, and skycaps and agents blame passengers. Less than one percent of all luggage is "mishandled," but it costs the airlines millions of dollars in claims. High-speed conveyors and lasers that scan bar-coded baggage tags may cut losses—or at least transfer the blame.

The Well-Rounded Rocket—The Scout rocket program made an inauspicious debut in the early 1960s with a failure rate of nearly 50 percent. But after 25 successful years of boosting U.S. and foreign satellites and probes to orbit, this mid-size expendable solid-fuel launcher has become—well, unexpendable.

GEORGE HALL

Heavy Metal—Even the designers of the B-52, who created the bomber in a hotel room in 1948, did not foresee it as the mainstay of the Strategic Air Command for the next 40 years. You can't keep a good airplane down, but maintenance crews have their hands full keeping this one up.

Legendary Leather—The classic flight jacket is back in Air Force cockpits, and boutiques are crammed with high-priced replicas. It's a trend one pilot calls "the Roscoe Turner syndrome."



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